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(54) **HEAT ASSISTED MAGNETIC RECORDING HEAD HAVING A PLURALITY OF DIFFUSION BARRIER LAYERS**

(71) Applicant: **Western Digital (Fremont), LLC**, Fremont, CA (US)

(72) Inventors: **Kris Vossough**, Redwood City, CA (US); **Marc A. Finot**, Palo Alto, CA (US); **John Love**, Livermore, CA (US); **Matthew R. Gibbons**, San Jose, CA (US); **Ge Yi**, San Ramon, CA (US); **Yufeng Hu**, Fremont, CA (US)

(73) Assignee: **WESTERN DIGITAL (FREMONT), LLC**, Fremont, CA (US)

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CPC ***G11B 5/4866*** (2013.01); ***G11B 5/127*** (2013.01); *G11B 5/314* (2013.01); *G11B 5/6088* (2013.01); *G11B 2005/0021* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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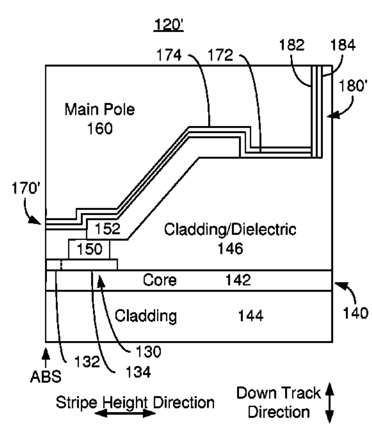
Primary Examiner — Tan X Dinh

(74) *Attorney, Agent, or Firm* — Convergent Law Group LLP

(57) **ABSTRACT**

A heat assisted magnetic recording (HAMR) writer is described. The HAMR writer is coupled with a laser and has an air-bearing surface (ABS) that resides near a media during use. The HAMR writer includes a waveguide, a near-field transducer (NFT), a main pole, coil(s) and at least one of a first and a second diffusion barrier layer. The waveguide is optically coupled with the laser and directs energy from the laser toward the ABS. The NFT is optically coupled with the waveguide and focuses the energy onto a region of the media. The main pole writes to the region of the media. The main pole has a top, a bottom, and a plurality of sides. The first diffusion barrier layer is between at least the NFT and the bottom of the pole. The second diffusion barrier layer is adjacent to the plurality of sides of the main pole.

20 Claims, 16 Drawing Sheets



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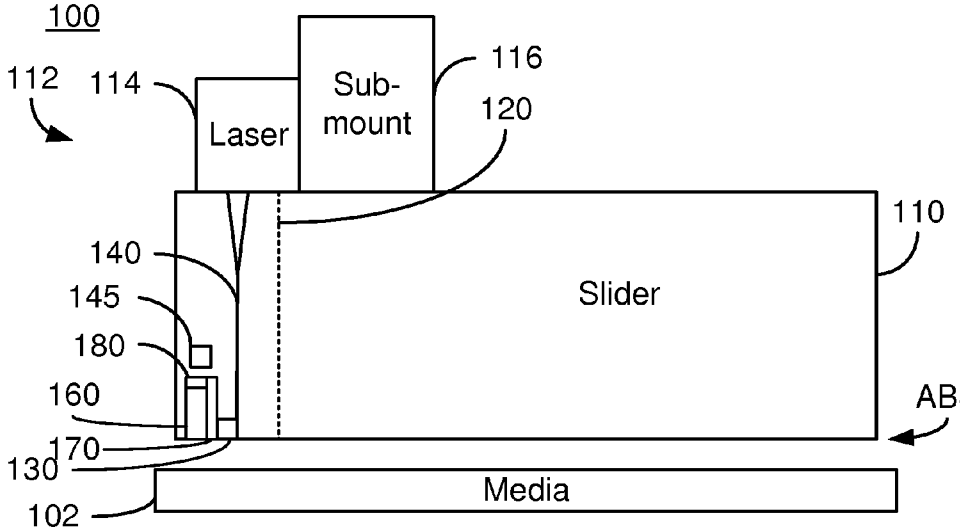
100
112
114
Laser
Sub-
mount
116
120
110
Slider
140
145
180
160
170
130
ABS
Media
102

FIG. 1

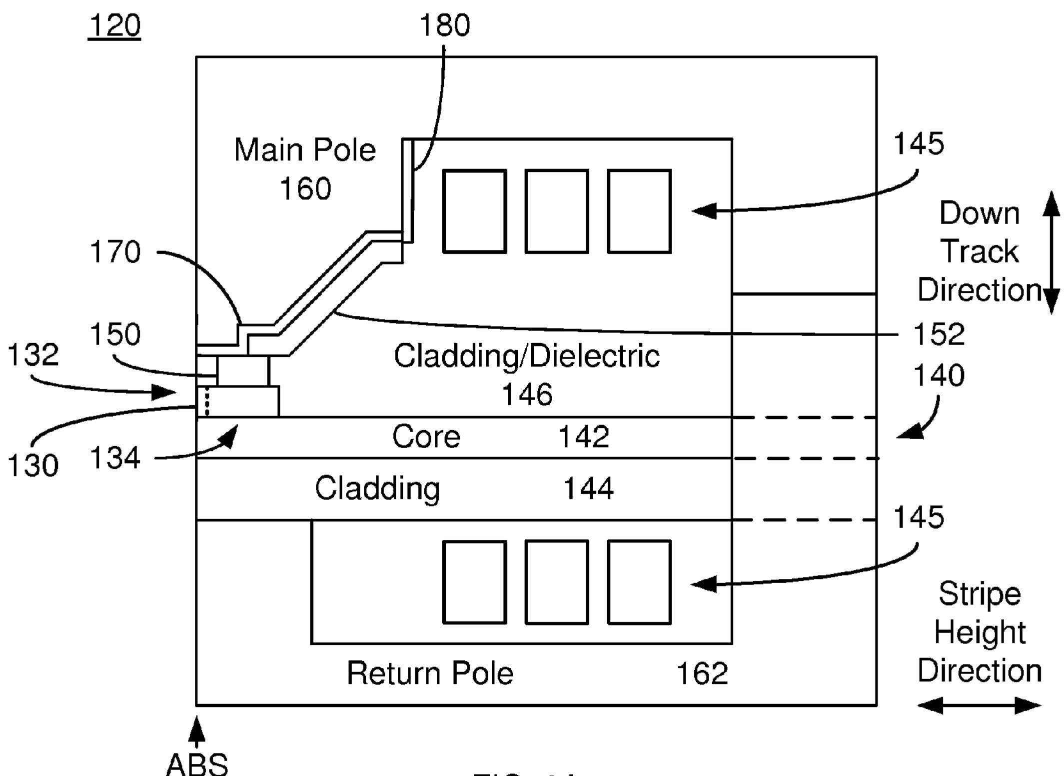
120
180
Main Pole
160
145
Down
Track
Direction
170
152
150
Cladding/Dielectric
146
132
140
130
134
Core 142
Cladding 144
145
Stripe
Height
Direction
Return Pole 162
ABS

FIG. 2A

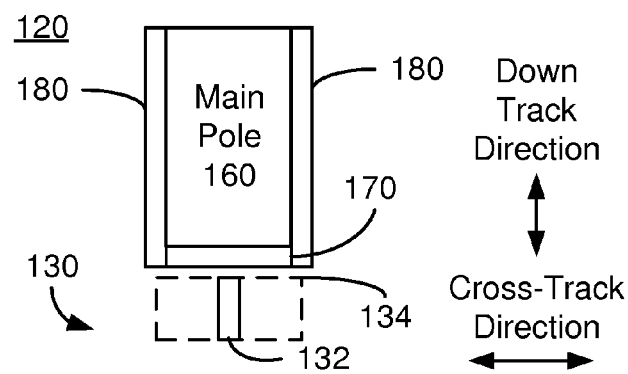

FIG. 2B

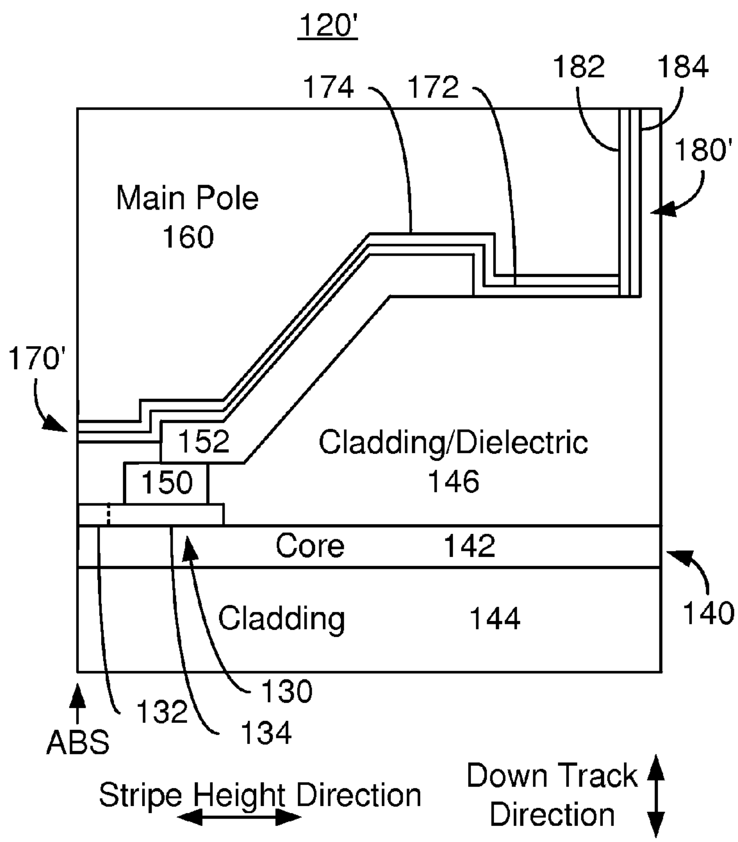

FIG. 3A

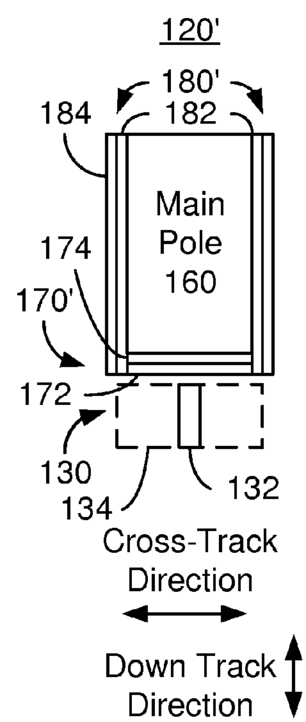

FIG. 3B

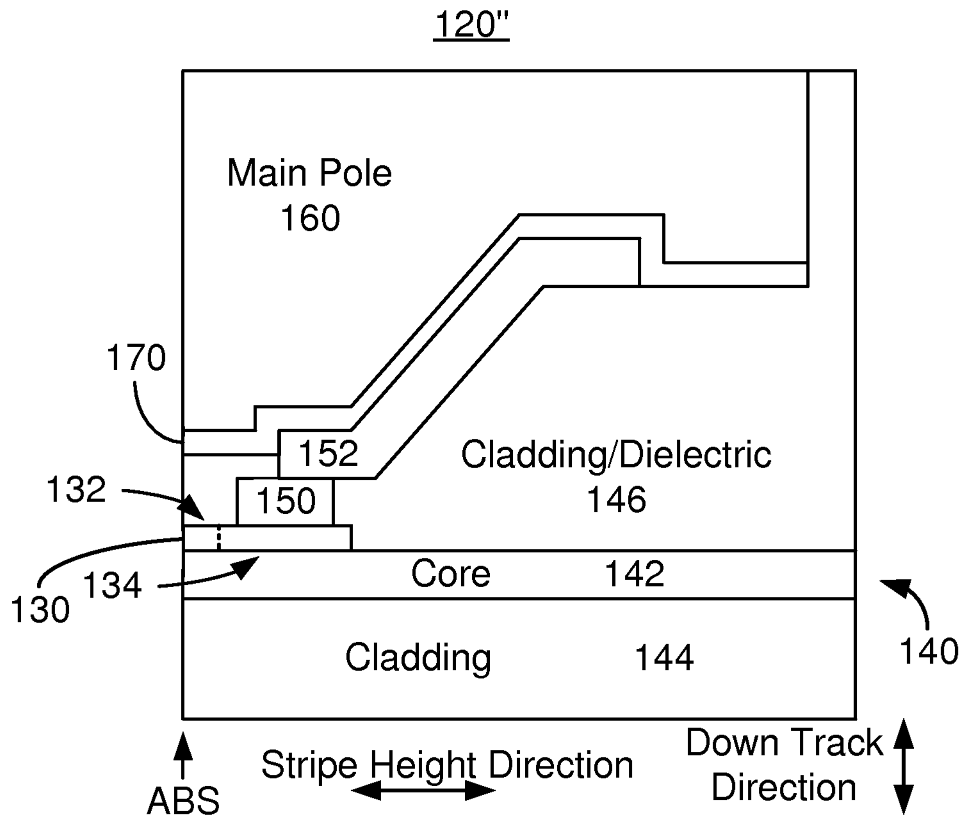
120"
Main Pole
160
170
152
Cladding/Dielectric
146
132
150
Core
142
130
134
Cladding
144
140
ABS
Stripe Height Direction
Down Track
Direction

FIG. 4A

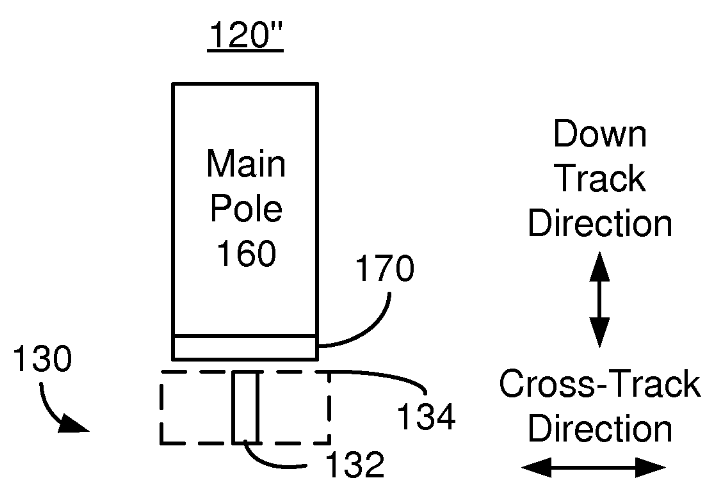
120"
Main
Pole
160
170
Down
Track
Direction
130
134
132
Cross-Track
Direction

FIG. 4B

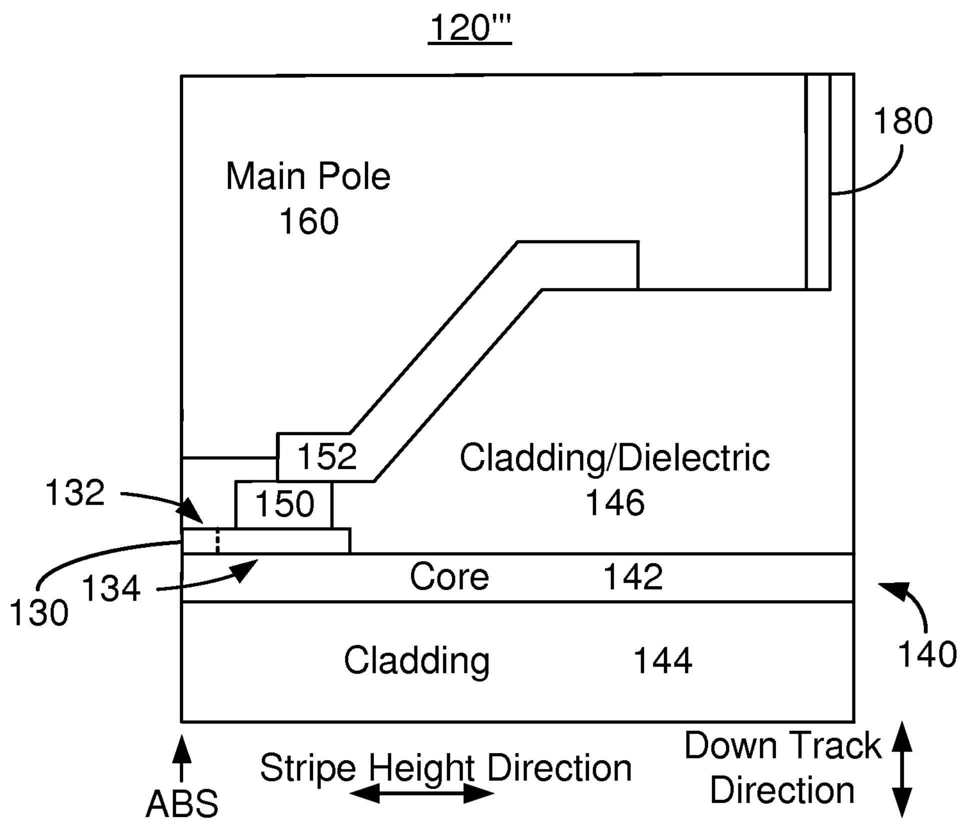
120'''
180
Main Pole
160
152
Cladding/Dielectric
146
132
150
134
Core
142
130
140
Cladding
144
ABS
Stripe Height Direction
Down Track
Direction

FIG. 5A

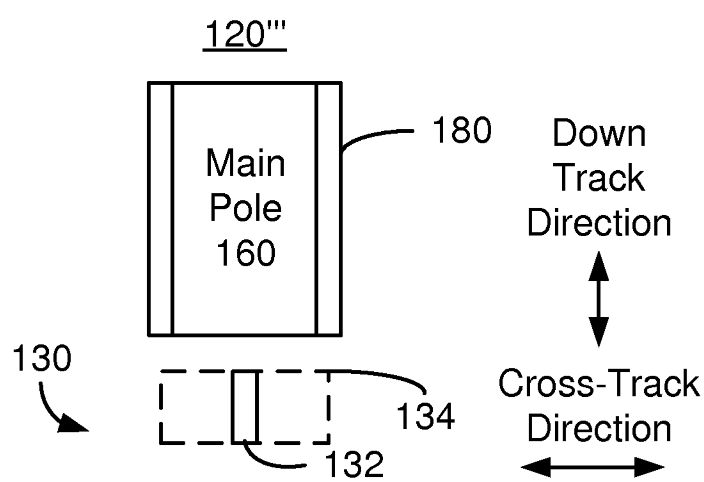
120'''
Main
Pole
160
180
Down
Track
Direction
130
134
132
Cross-Track
Direction

FIG. 5B

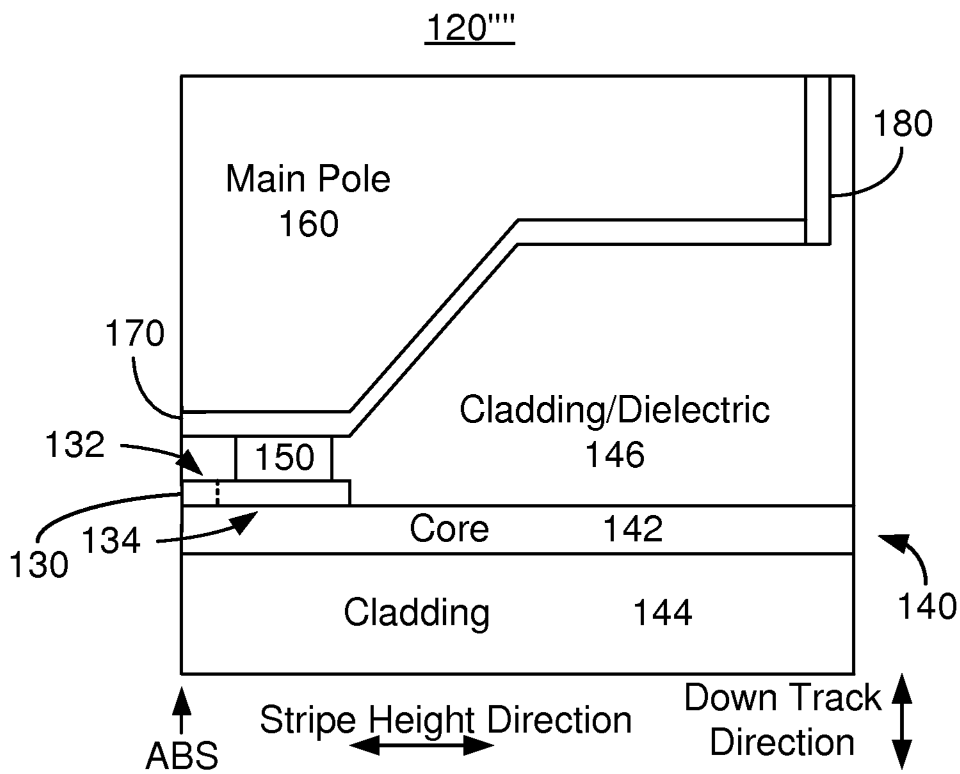
120''''
Main Pole
160
180
170
Cladding/Dielectric
146
132
150
130
134
Core
142
Cladding
144
140
ABS
Stripe Height Direction
Down Track
Direction

FIG. 6A

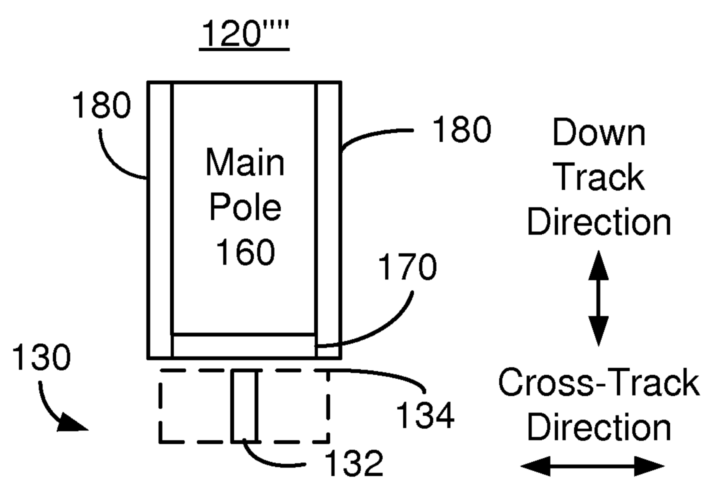
120''''
180
Main
Pole
160
180
170
130
134
132
Down
Track
Direction
Cross-Track
Direction

FIG. 6B

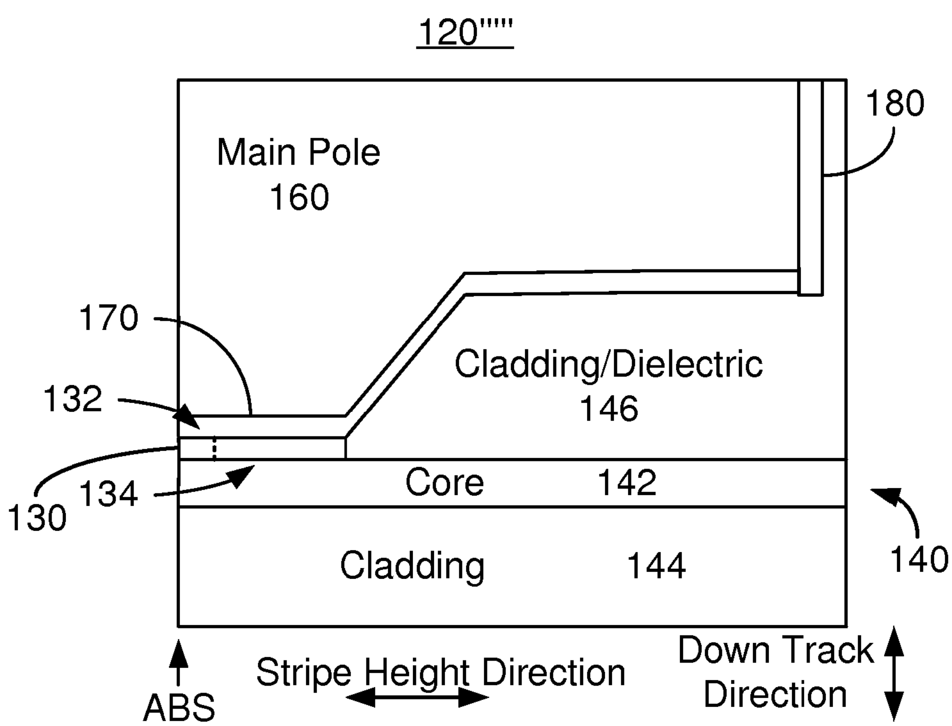
120'''''
Main Pole
160
180
170
132
Cladding/Dielectric
146
130
134
Core
142
140
Cladding
144
ABS
Stripe Height Direction
Down Track
Direction

FIG. 7A

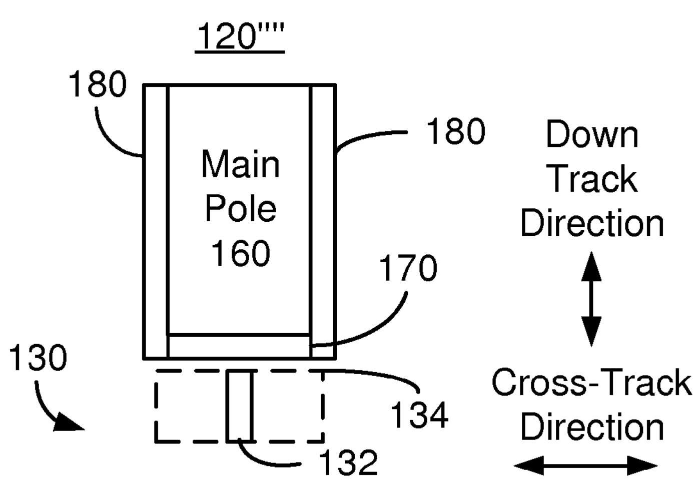
120''''
180
180
Main
Pole
160
Down
Track
Direction
170
130
134
132
Cross-Track
Direction

FIG. 7B

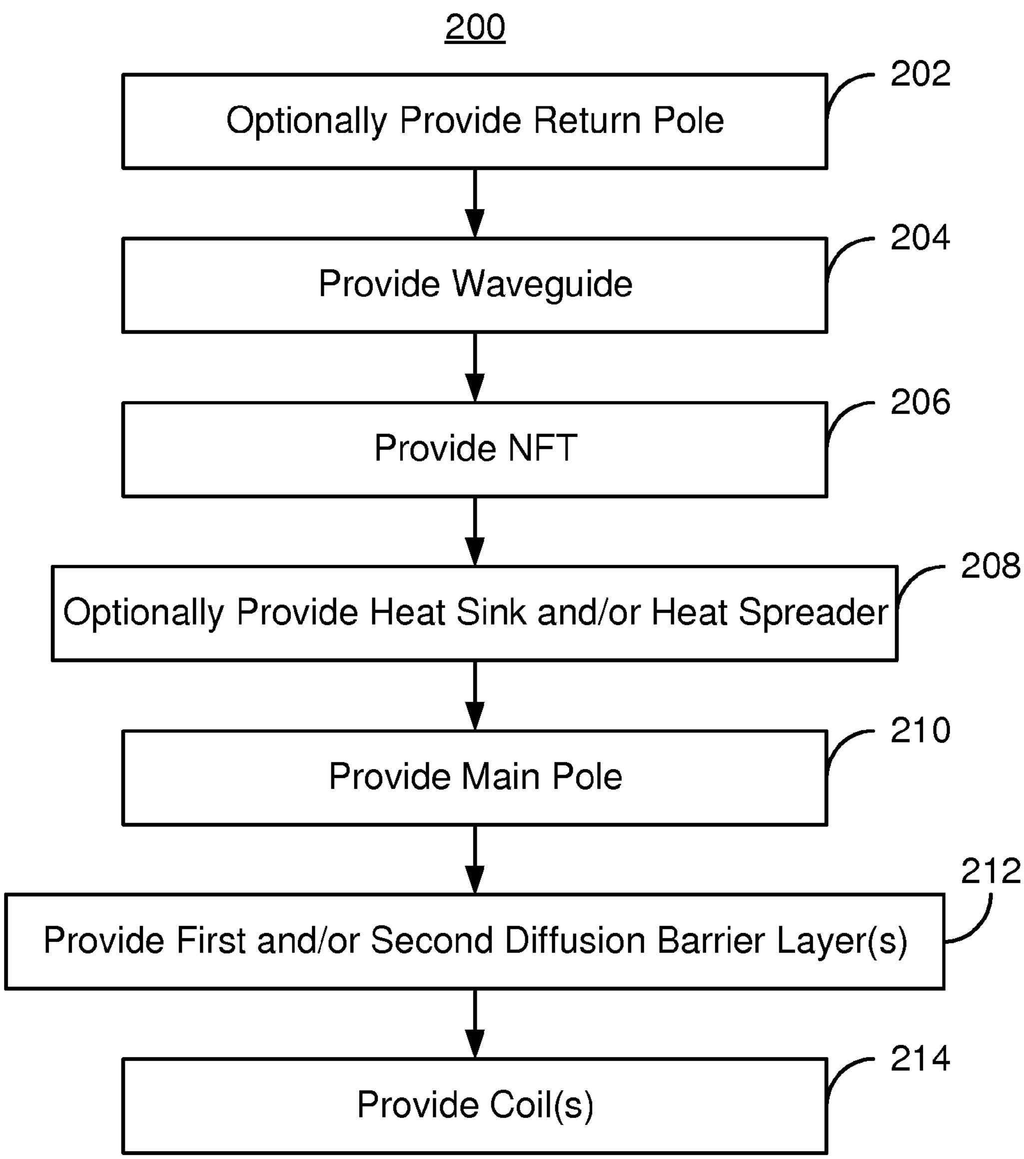
200
Optionally Provide Return Pole
202
Provide Waveguide
204
Provide NFT
206
Optionally Provide Heat Sink and/or Heat Spreader
208
Provide Main Pole
210
Provide First and/or Second Diffusion Barrier Layer(s)
212
Provide Coil(s)
214

FIG. 8

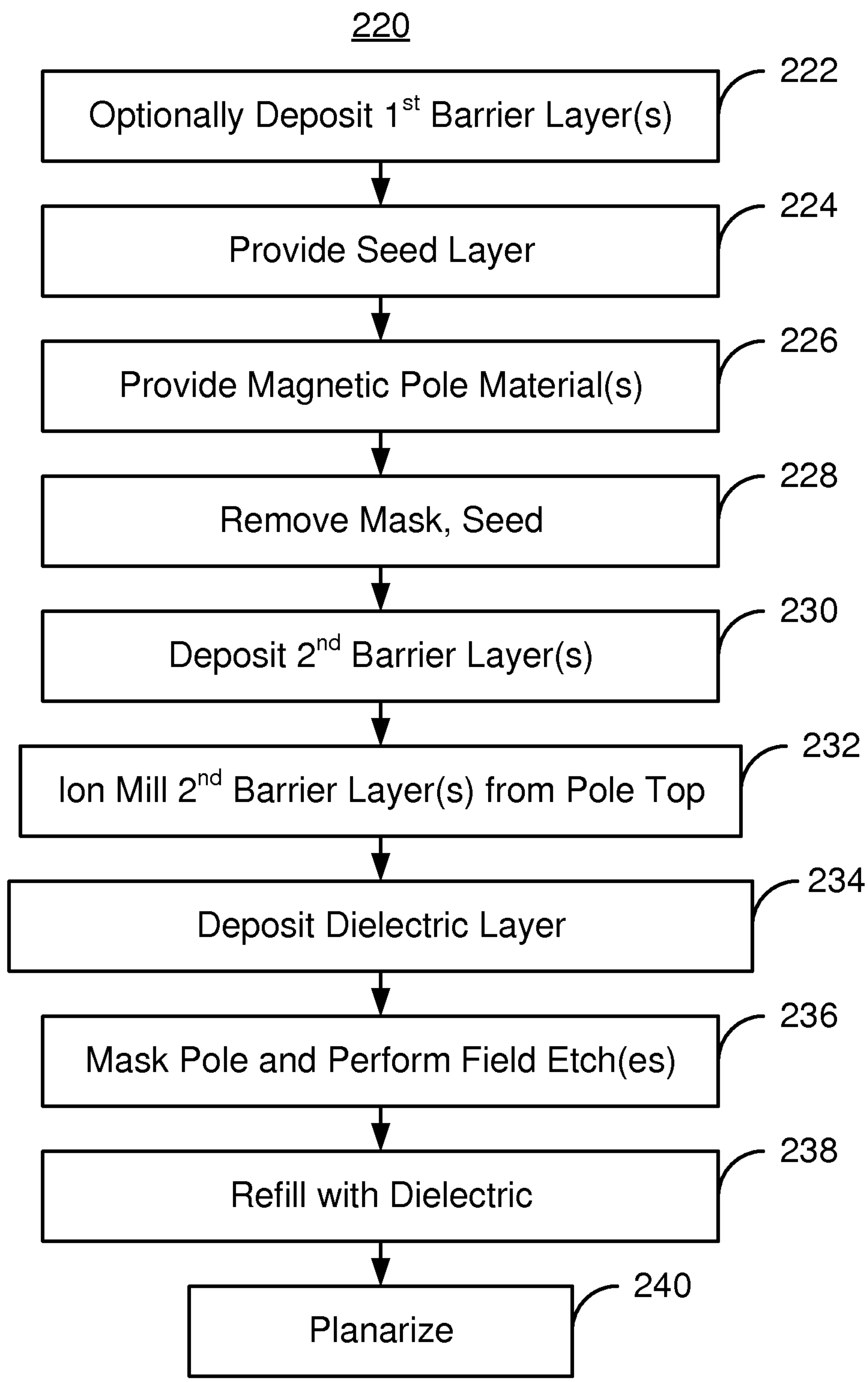
220
Optionally Deposit 1st Barrier Layer(s)
222
Provide Seed Layer
224
Provide Magnetic Pole Material(s)
226
Remove Mask, Seed
228
Deposit 2nd Barrier Layer(s)
230
Ion Mill 2nd Barrier Layer(s) from Pole Top
232
Deposit Dielectric Layer
234
Mask Pole and Perform Field Etch(es)
236
Refill with Dielectric
238
Planarize
240

FIG. 9

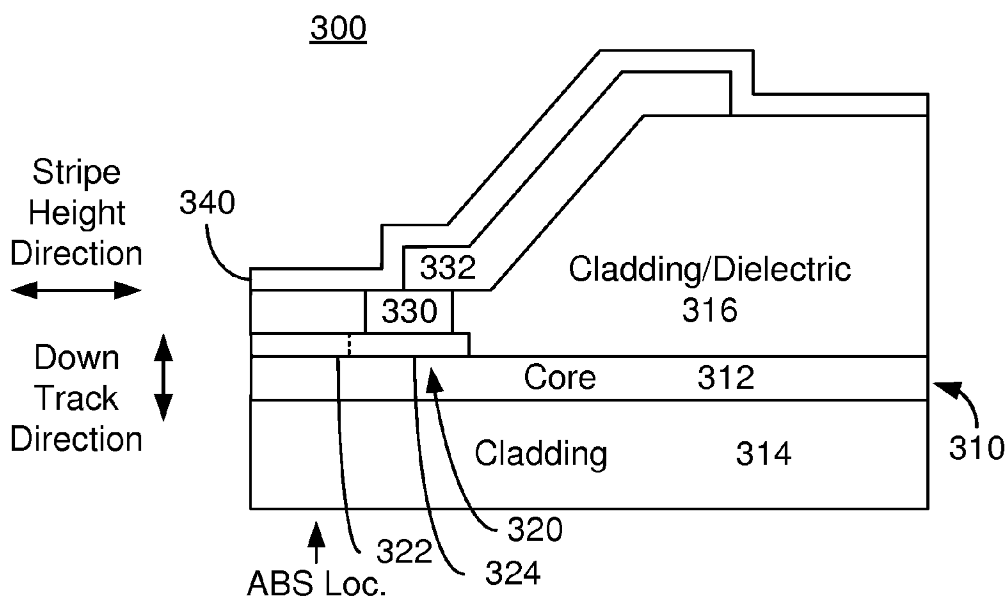
300
Stripe Height Direction
Down Track Direction
340
332
330
Cladding/Dielectric
316
Core 312
Cladding 314
310
320
322
324
ABS Loc.

FIG. 10

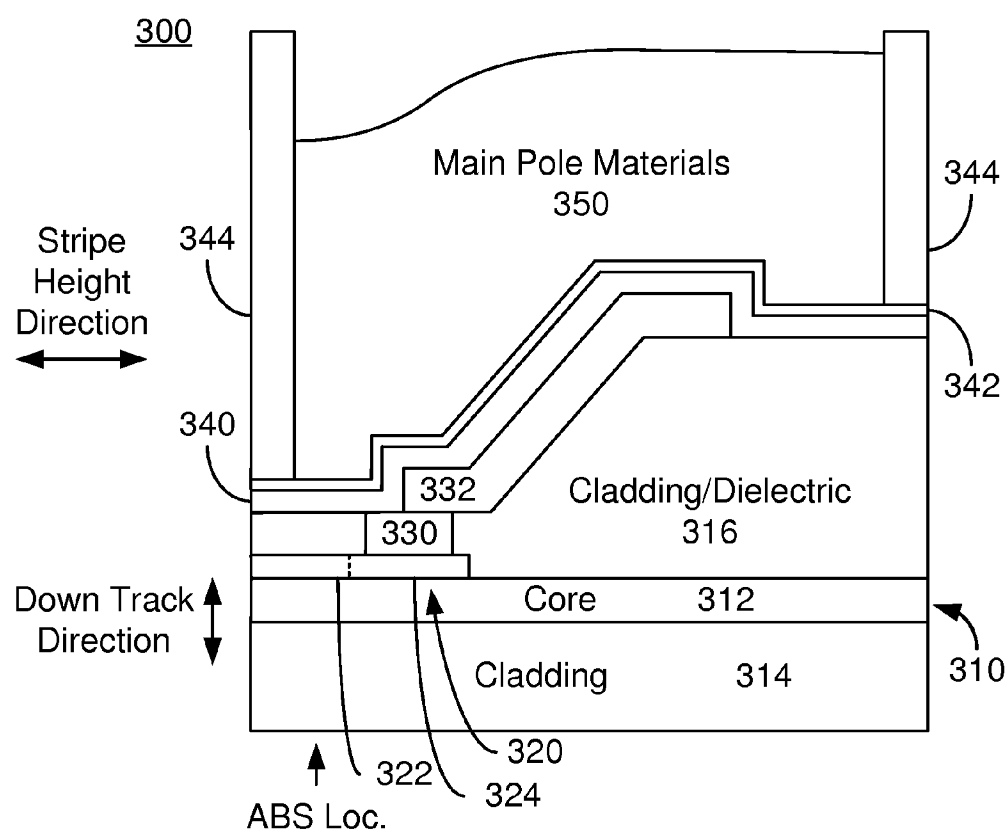
300
Main Pole Materials
350
344
344
342
Stripe Height Direction
340
332
330
Cladding/Dielectric
316
Down Track Direction
Core 312
Cladding 314
310
320
322
324
ABS Loc.

FIG. 11

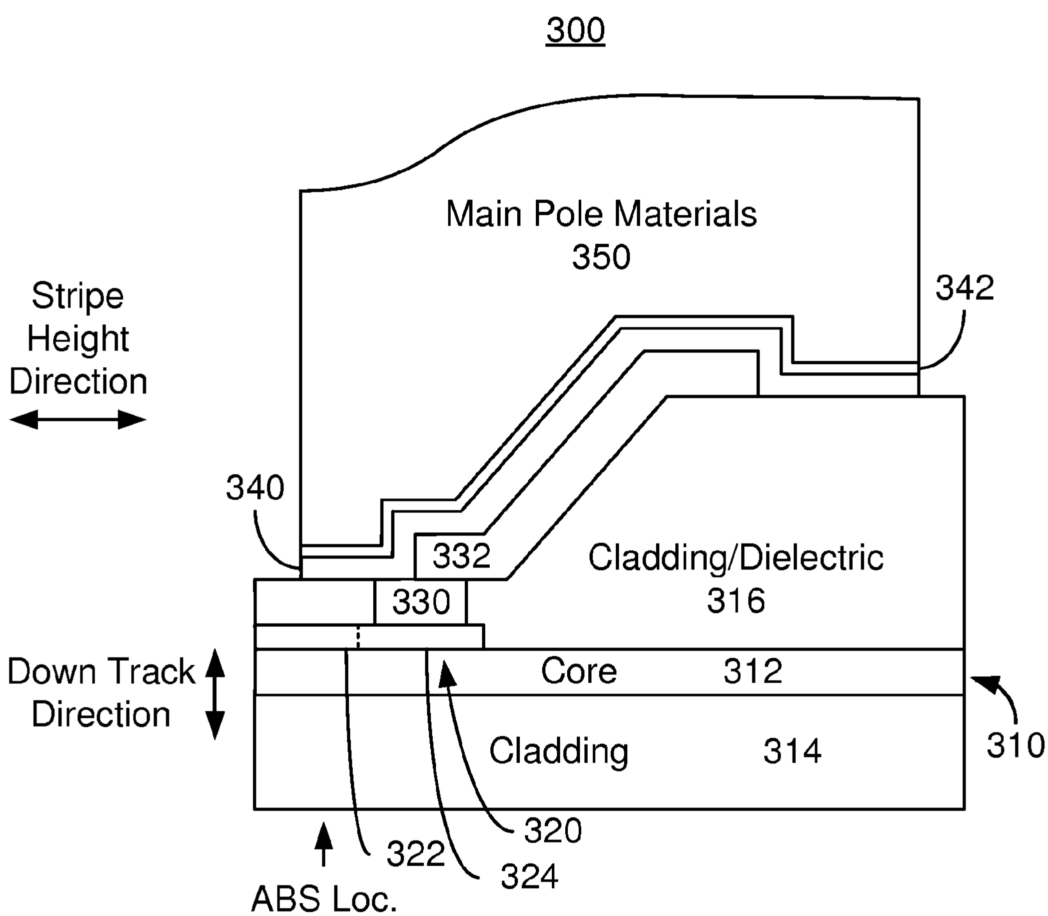
300
Main Pole Materials
350
342
Stripe
Height
Direction
340
332
Cladding/Dielectric
316
330
Down Track
Direction
Core
312
Cladding
314
310
320
322
324
ABS Loc.

FIG. 12

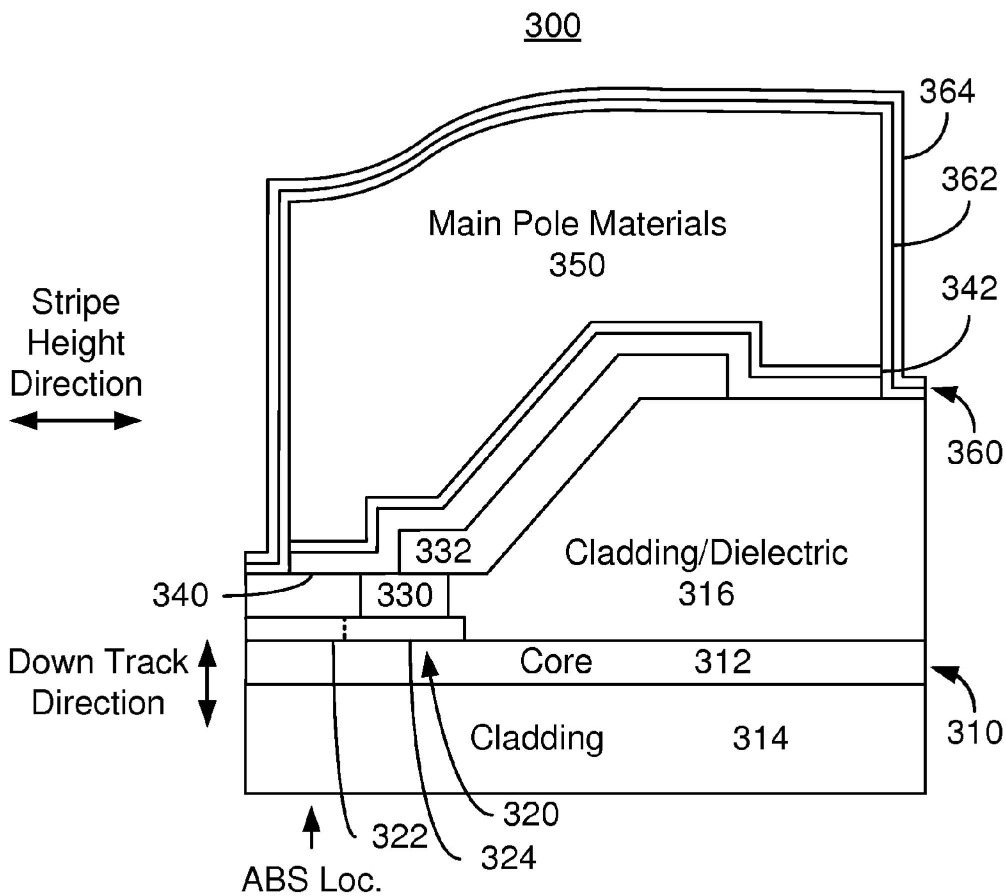
300
Main Pole Materials
350
364
362
342
360
Stripe
Height
Direction
332
Cladding/Dielectric
316
340
330
Down Track
Direction
Core
312
Cladding
314
310
320
322
324
ABS Loc.

FIG. 13

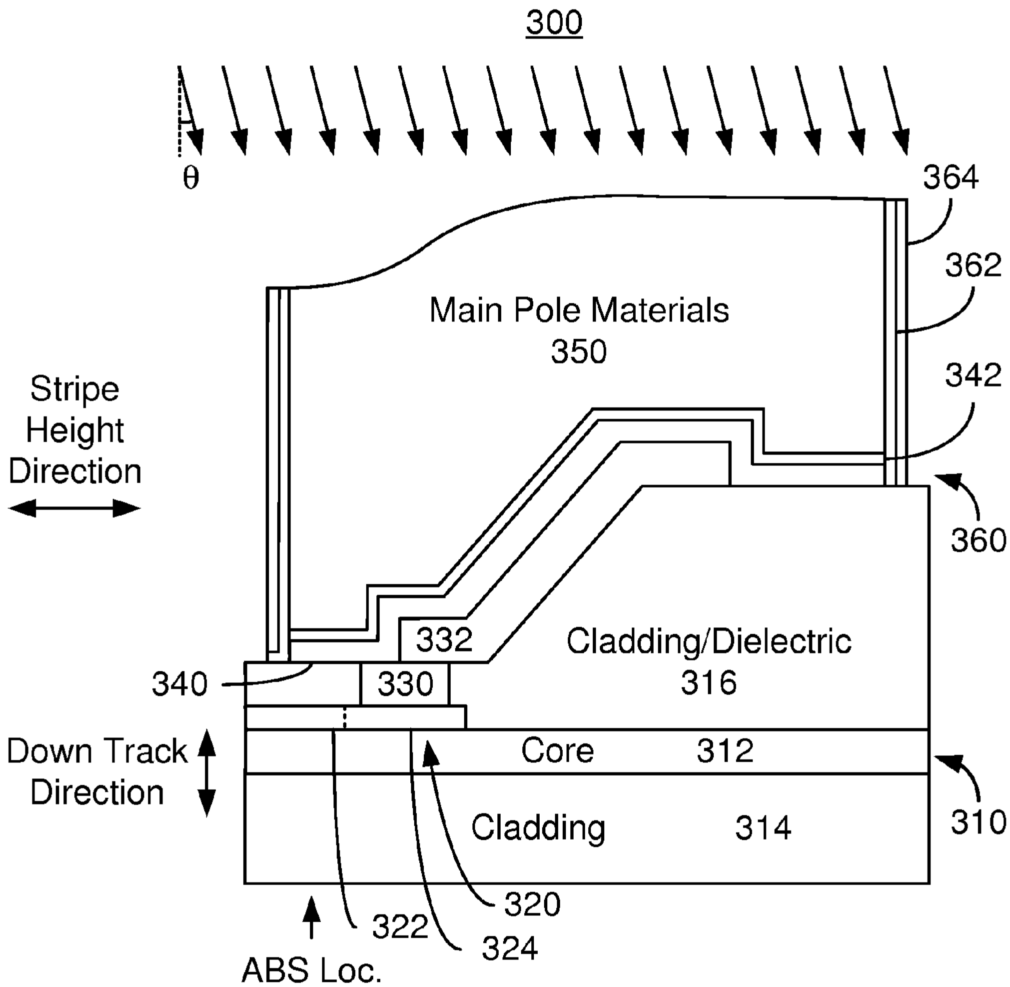
300
θ
364
362
342
360
Main Pole Materials
350
Stripe
Height
Direction
332
Cladding/Dielectric
316
340
330
Down Track
Direction
Core
312
Cladding
314
310
320
322
324
ABS Loc.

FIG. 14

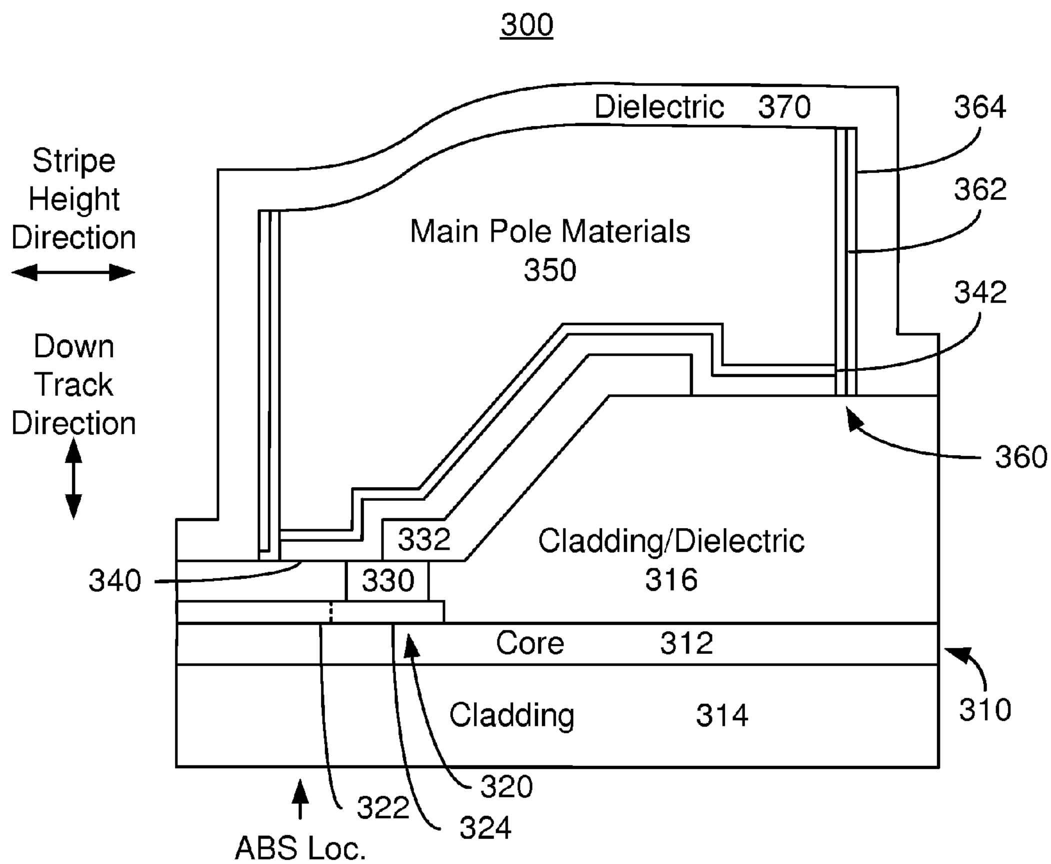
300
Dielectric 370
364
362
342
360
Main Pole Materials
350
Stripe
Height
Direction
Down
Track
Direction
332
330
340
Cladding/Dielectric
316
Core 312
Cladding 314
310
320
322
324
ABS Loc.

FIG. 15

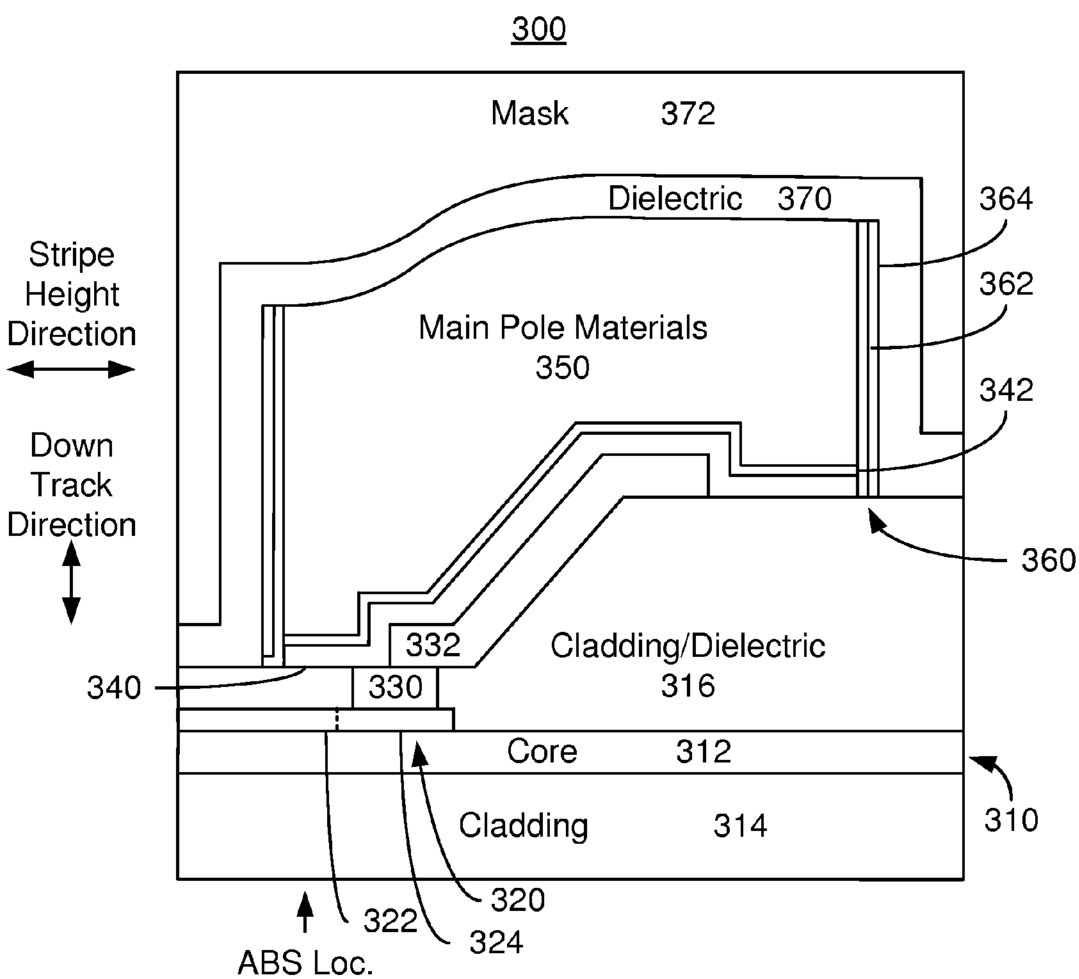
300
Mask 372
Dielectric 370
364
362
342
Stripe Height Direction
Main Pole Materials 350
Down Track Direction
360
332
Cladding/Dielectric 316
340
330
Core 312
Cladding 314
310
320
322
324
ABS Loc.

FIG. 16

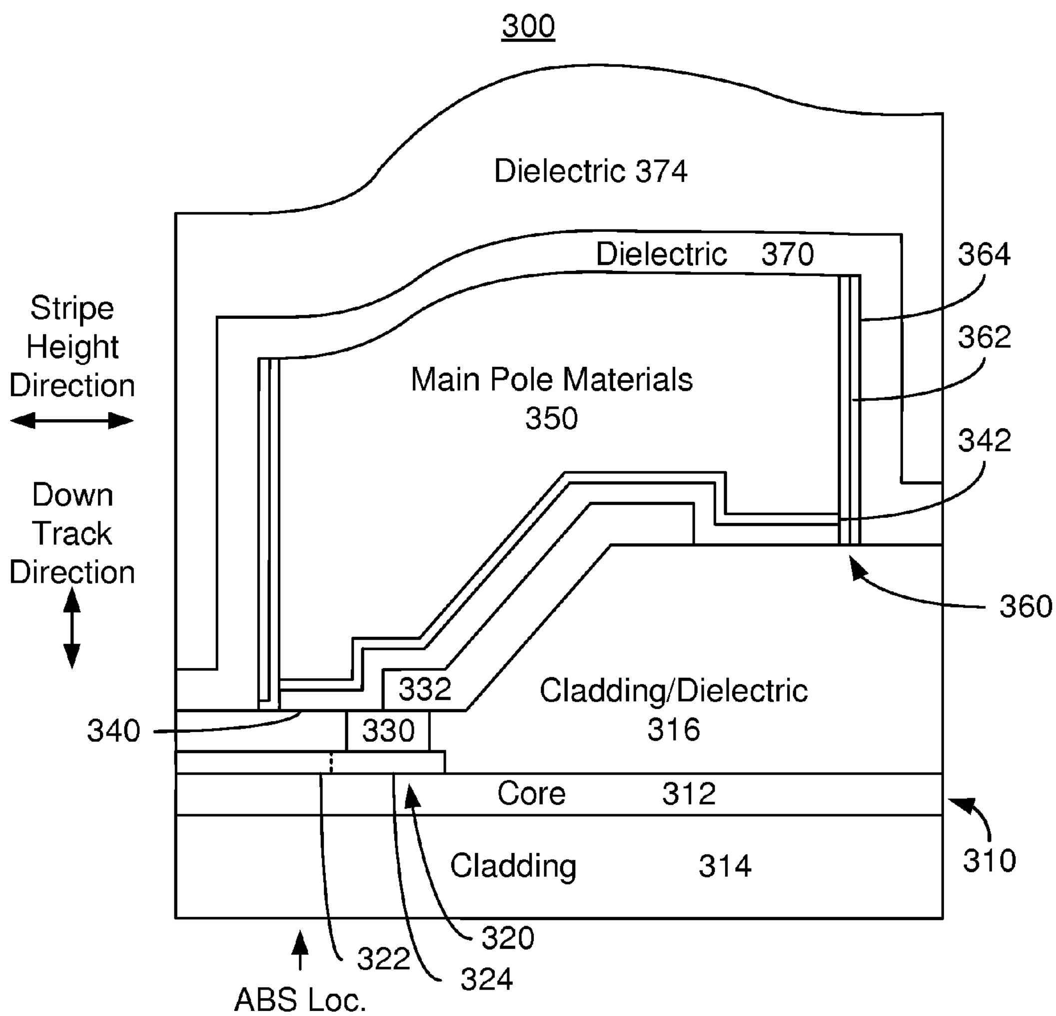
300
Dielectric 374
Dielectric 370
364
362
342
Stripe Height Direction
Main Pole Materials
350
Down Track Direction
360
332
Cladding/Dielectric
316
340
330
Core 312
310
Cladding 314
320
322
324
ABS Loc.

FIG. 17

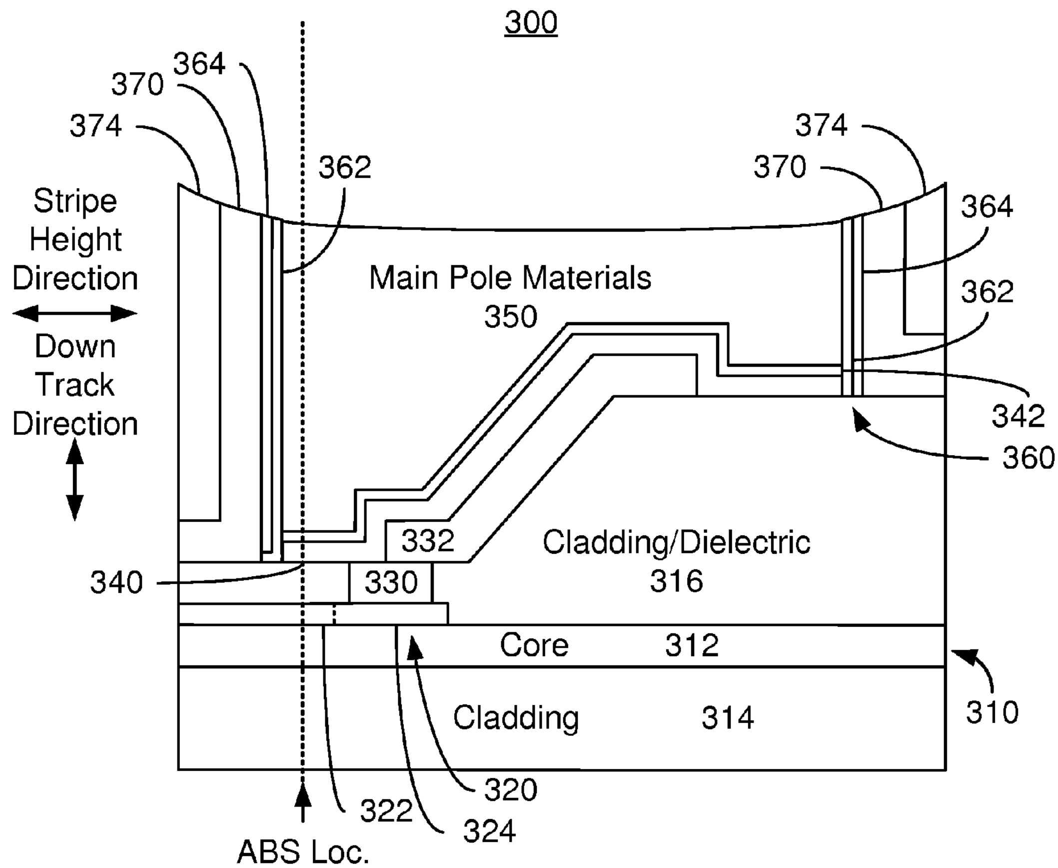
300
374
370
364
362
Stripe Height Direction
Down Track Direction
Main Pole Materials 350
374
370
364
362
342
360
332
330
Cladding/Dielectric 316
340
Core 312
Cladding 314
310
320
322
324
ABS Loc.

FIG. 18

HEAT ASSISTED MAGNETIC RECORDING HEAD HAVING A PLURALITY OF DIFFUSION BARRIER LAYERS

BACKGROUND

A conventional heat assisted magnetic recording (HAMR) transducer typically includes at least a waveguide, a near-field transducer (NFT), a main pole and a coil for energizing the main pole. The conventional HAMR transducer uses light, or energy, received from a conventional laser in order to write to a magnetic recording media. Light from the laser is incident on and coupled into the waveguide. Light is guided by the conventional waveguide to the NFT **20** near the ABS. The NFT focuses the light to magnetic recording media (not shown), such as a disk. This region is thus heated. The main pole is energized and field from the pole tip is used to write to the heated portion of the recording media.

Although the conventional HAMR transducer functions, there are drawbacks. During use, the NFT and surrounding region, including the main pole tip and waveguide, may be subjected to very high temperatures. As a result, the structure and performance of the NFT, waveguide and/or write pole may be degraded. Performance and reliability of the conventional HAMR transducer may thus be adversely affected.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a diagram depicting a side view of an exemplary embodiment of a HAMR disk drive.

FIGS. **2**A and **2**B are diagrams depicting side and ABS views of an exemplary embodiment of a HAMR transducer.

FIGS. **3**A and **3**B are diagrams depicting side and ABS views of another exemplary embodiment of a HAMR transducer.

FIGS. **4**A and **4**B are diagrams depicting side and ABS views of another exemplary embodiment of a HAMR transducer.

FIGS. **5**A and **5**B are diagrams depicting side and ABS views of another exemplary embodiment of a HAMR transducer.

FIGS. **6**A and **6**B are diagrams depicting side and ABS views of another exemplary embodiment of a HAMR transducer.

FIGS. **7**A and **7**B are diagrams depicting side and ABS views of another exemplary embodiment of a HAMR transducer.

FIG. **8** is a flow chart depicting an exemplary embodiment of a method for fabricating a HAMR write transducer.

FIG. **9** is a flow chart depicting an exemplary embodiment of a method for fabricating a main pole and a diffusion barrier layer of a HAMR write transducer.

FIGS. **10**-**18** are diagrams depicting side views of another exemplary embodiment of a HAMR transducer during fabrication using the method described herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** depicts a side view of an exemplary embodiment of a portion of a heat-assisted magnetic recording (HAMR) disk drive **100**. For clarity, FIG. **1** is not to scale. For simplicity not all portions of the HAMR disk drive **100** are shown. In addition, although the HAMR disk drive **100** is depicted in the context of particular components other and/or different components may be used. For example, circuitry used to drive and control various portions of the HAMR disk drive **100** is not shown. For simplicity, only single components are shown. However, multiples of each component and their sub-components, might be used.

The HAMR disk drive **100** includes media **102**, a slider **110**, a laser subassembly **112** and a HAMR transducer **120**. Additional and/or different components may be included in the HAMR disk drive **100**. Although not shown, the slider **110**, and thus the laser assembly **112** and HAMR transducer **120** are generally attached to a suspension (not shown). The laser assembly **112** includes a laser **114** and a submount **116**. The submount **116** is a substrate to which the laser **114** may be affixed for improved mechanical stability, ease of manufacturing and better robustness. The laser **114** may be a chip such as a laser diode or other laser.

The HAMR transducer **120** is fabricated on the slider **110** and includes an air-bearing surface (ABS) proximate to the media **102** during use. In general, the HAMR write transducer **120** and a read transducer are present in the HAMR head. However, for clarity, only the HAMR write transducer **120** is shown. As can be seen in FIG. **1**, HAMR transducer **120** includes a near-field transducer (NFT) **130**, a waveguide **140**, coil(s) **145**, a main pole **160** and diffusion barrier layers **170** and **180**. The waveguide **140** is optically coupled with the laser **114** and carries light energy from the laser **114** to the ABS. The NFT **130** couples a portion of this energy from the waveguide **140** to the media **102**. In some embodiments, the NFT **130** occupies a portion of the ABS. The NFT **130** transfers energy to the media **102**. The write pole **160** is energized by the coils **145** and writes to the media **102**.

One or more diffusion barrier layers **170** and **180** may also be present. The diffusion barrier **170** is adjacent to the bottom of the main pole **160** and resides between the main pole **160** and the NFT **130**. In some embodiments, the diffusion barrier **170** adjoins the bottom of the main pole **160**. The diffusion barrier **180** resides adjacent to the sides of the main pole **160**. In the embodiment shown, the diffusion barrier **180** is at least at the back of the main pole. In some embodiments, the diffusion barrier layer **180** is adjacent to the sides of the main pole **160**. The diffusion barrier layer **180** may be adjacent to both the back and sides of the main pole **160**. In some embodiments, the diffusion barrier **180** adjoins the sides and/or back of the main pole **160**. Although the structures **170** and **180** are both diffusion barriers, the structures **170** and **180** may be configured to reduce or prevent diffusion of different materials. In some embodiments, diffusion barrier layers **170** and **180** are present. In other embodiments, one of the diffusion barrier layers **170** or **180** may be omitted.

The diffusion barrier layer **170** is desired to insulate the write pole **160** from diffusion of material(s) such as those in the NFT **130**. The diffusion barrier layer **170** may also prevent or reduce diffusion of materials used in a heat sink and/or heat spreader (not shown in FIG. **1**) that lie along the bottom of the main pole. Thus, the diffusion barrier layer **170** includes a barrier to diffusion of a gold-containing material. In some embodiments, the diffusion barrier layer **170** may be a multilayer. For example, the diffusion barrier layer **170** may include at least one of a W layer, a Ru layer, a Ta layer, a TaN layer, an indium oxide layer, a tungsten nitride layer, a titanium nitride layer, a titanium tungsten layer, a tungsten carbonitride layer, a tungsten disilicide layer, a titanium tungsten silicide layer and a Ni layer. The diffusion barrier layer **170** may have a thickness of at least five nanometers and not more than twelve nanometers. For example, the diffusion barrier layer **170** may consist of a ten nanometer W layer. Alternatively, a ten nanometer Ta layer may be used.

In contrast, the diffusion barrier layer **180** may include a barrier to diffusion of constituent(s) of the main pole **160**. Thus, one or more materials in the main pole **160** may be prevented from diffusing to the surrounding dielectric. For example, the diffusion barrier layer **180** be a barrier to diffusion of Fe in the main pole **160**. For example, the diffusion barrier layer **180** may include at least one of W and Ru. In some embodiments, the diffusion barrier layer **180** is a single layer. In other embodiments, the diffusion barrier layer **180** may be a multilayer including multiple sublayers. For example, the second diffusion barrier layer **180** may include a W sublayer and a Ru sublayer on the W sublayer. In some embodiments, the same material(s) may be used for the diffusion barrier layer **170** as the diffusion barrier layer **180**. For example, W may be used for both structures **170** and **180**.

The HAMR disk drive **100** may exhibit enhanced performance. More specifically, the presence of the diffusion barrier layer **170** and/or **180** may improve the HAMR transducer **100**. The diffusion barrier layer **170** may prevent or reduce diffusion of portions of the NFT **130** or other analogous materials into the main pole **160**. Similarly, the diffusion barrier layer **180** may prevent or reduce diffusion of portions of the main pole **160** into the surrounding structures. Thus, intermixing of the layers of the transducer **120** may be reduced. The desired properties of components of the transducer **120** may be maintained and failure of the components prevented. Thus, performance and reliability of the HAMR transducer **130** and the disk drive **100** may be enhanced.

FIGS. **2**A and **2**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120** that is part of the disk drive **100**. For clarity, FIGS. **2**A and **2**B are not to scale. For simplicity not all portions of the HAMR transducer **120** are shown. In addition, although the HAMR transducer **120** is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120** may be used in the HAMR disk drive **100**. Consequently, similar components have analogous labels. In addition, the HAMR transducer **120** is discussed in the context of the disk drive **100**.

The HAMR transducer **120** includes NFT **130**, waveguide **140**, write pole **160**, return pole **162** and coils **145**. The coil(s) **145** may be spiral, or pancake, coils. In other embodiments, the coil(s) **145** may be solenoidal. The coil(s) **145** may be used to energize the write pole **140** during writing.

The waveguide **140** directs energy from the laser **114** to the ABS. The waveguide **140** includes cladding **144** and **146** as well as core **142**. The NFT **130** is optically coupled with the waveguide **140** and receives energy from the core **142**. The NFT **130** is proximate to the ABS. For example, the NFT **130** is shown as having a surface occupying a portion of the ABS. The NFT **130** is depicted as including a pin **132** and a disk **134**. The pin **132** is between the disk **134** and the ABS. The disk **134** is recessed from the ABS and thus is shown by a dashed line in the ABS view of FIG. **3**B. The pin **132** is also relatively short. Consequently, the disk **134** may be recessed from the ABS by not more than fifty nanometers. Although termed a disk, the disk **134** of the NFT **130** need not be disk-shaped. For example, instead of having a circular footprint, the disk **134** may be square, rectangular, or have another shape.

The write pole **160** is configured to write to the region of the media heated by the NFT **130**. In some embodiments, the write pole **160** does not extend more than across the disk **134** of the NFT in the track width direction in the pole tip region. Thus, for example, the width of the write pole **160** in the track width direction at the ABS may be less than two hundred nanometers.

In the embodiment shown, a heat sink **150** and heat spreader **152** are also included in the transducer **120**. In alternate embodiment, one or both structures **150** and/or **152** may be omitted. The heat sink **150** is thermally coupled with the NFT **130** and the main pole **160**. The heat spreader **152** may also be thermally connected with the NFT **130** and the main pole **160**. The heat sink **150** and heat spreader **152** may be used in thermal management for the transducer **120**. Thus, the heat sink **150** and heat spreader **152** are desired to have a high thermal conductivity. For example, a material such as gold or a gold alloy may be used for the heat sink **150** and/or the heat spreader **152**. The materials used for the heat sink **150** and heat spreader **152** may be similar to materials used in the NFT **130**. The heat sink **150** and heat spreader **152** may be used to conduct heat from the NFT **130** and allow for heat dissipation over a wider area of the HAMR transducer **120**.

Diffusion barrier layers **170** and **180** are also shown in FIGS. **2**A and **2**B. The diffusion barrier layer **170** resides between the NFT **130** and the main pole **160**. More specifically, the diffusion barrier layer **170** is between the main pole **160** and both the heat sink **150** and heat spreader **152**. The diffusion barrier layer **170** adjoins the bottom of the main pole **170**. The diffusion barrier layer **170** is desired to insulate the write pole **160** from diffusion of material(s) in the NFT **130**, heat sink **150** and heat spreader **152**. Thus, the diffusion barrier layer **170** includes a barrier to diffusion of a gold-containing material. For example, the diffusion barrier layer **170** may include at least one of a W layer, a Ru layer, a Ta layer, a TaN layer, an indium oxide layer, a tungsten nitride layer, a titanium nitride layer, a titanium tungsten layer, a tungsten carbonitride layer, a tungsten disilicide layer, a titanium tungsten silicide layer and a Ni layer. The diffusion barrier layer **170** may have a thickness sufficient to prevent diffusion of material(s) such as Au used in the structures **130**, **150** and/or **152** into the main pole.

The diffusion barrier layer **180** resides on the back and sides of the main pole **160**, as shown in FIGS. **2**A (back) and **2**B (sides). The diffusion barrier layer **180** may include a barrier to diffusion of constituent(s) of the main pole **160**. For example, the diffusion barrier layer **180** be a barrier to diffusion of Fe in the main pole **160**. In addition, another barrier, such as an oxygen diffusion barrier, may be included in the diffusion barrier layer **180**. The diffusion barrier layer **180** may include at least one of W and Ru. In the embodiment shown, the diffusion barrier layer **180** is a single layer. In some embodiments, the same material(s) may be used for the diffusion barrier layer **170** as the diffusion barrier layer **180**. For example, W may be used for both structures **170** and **180**.

In some embodiments, the diffusion barrier layer(s) **170** and/or **180** may be configured to reduce or prevent corrosion, particularly corrosion that is galvanic in nature. For example, the barrier layer **170** and/or **180** may be a dielectric layer or include a dielectric layer. Such a dielectric layer may be on the order of at least five and not more than ten nanometers. For example, metal oxides such as Ta_2O_5, Nb_2O_5 and/or V_2O_5 might be used. In other embodiments, multilayers of different oxide stacks, ternary oxides, combinations of oxides and metals or conductive metal nitrides and/or silicides such as TaN, TiN, and/or WSi_2 might be used. Insertion of such a dielectric layer may break or inhibit galvanic coupling that may be a source of corrosion. Corrosion of the main pole **160** may thus be reduced or eliminated. If the diffusion barrier layers are so configured, the diffusion barrier layers **170** and/or **180** may be considered to be corrosion barrier layers. In embodiments in which the layers **170** and/or **180** are multilayers, the layers in the multilayer may have different functions. For example, one layer might be a metallic diffusion barrier layer, while another layer may be a corrosion barrier layer. In other embodiments, a single dielectric may perform the dual functions of a diffusion barrier and a corrosion barrier. Thus, the diffusion barrier layers **170** and/or **180** may be both diffusion barriers and corrosion barriers in some embodiments.

The HAMR transducer **120** may exhibit enhanced performance due to the presence of the diffusion barrier layer **170** and/or **180**. The diffusion barrier layer **170** may prevent or reduce diffusion of portions of the NFT **130**, heat sink **150** and/or heat spreader **152** or other analogous materials into the main pole **160**. Similarly, the diffusion barrier layer **180** may prevent or reduce diffusion of portions of the main pole **160** into the surrounding structures such as the dielectric **146**. Thus, intermixing of the layers of the transducer **120** may be reduced. Thus, performance and reliability of the HAMR transducer **120** and the disk drive **100** may be enhanced. In some embodiments, corrosion of the pole may also be reduced by the diffusion barrier layer(s) **170** and/or **180**.

FIGS. **3**A and **3**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120'** that may be part of the disk drive **100**. For clarity, FIGS. **3**A and **3**B are not to scale. For simplicity not all portions of the HAMR transducer **120'** are shown. In addition, although the HAMR transducer **120'** is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120'** is analogous to the HAMR transducer **120**. Consequently, similar components have analogous labels. The HAMR transducer **120'** thus includes an NFT **130** including a disk **134** and a pin **130**, a waveguide **140** including cladding **144** and **146** and core **142**, heat sink **150**, heat spreader **152**, main pole **160**, diffusion barrier layer **170'** and diffusion barrier layer **180'** that are analogous to the NFT **130** having the disk **134** and the pin **130**, the waveguide **140** including cladding **144** and **146** and core **142**, the heat sink **150**, the heat spreader **152**, the main pole **160**, the diffusion barrier layer **170** and the diffusion barrier layer **180**, respectively. The structure and function of the components in the transducer **120'** are thus analogous to those of the transducer **120**. In addition, for clarity, some components of the transducer **120'** are not shown. For example, coils and the return pole depicted in FIG. **2**A are not shown in FIG. **3**A. However, such structures may be present.

In the embodiment shown in FIGS. **3**A and **3**B, the diffusion barrier layer **170'** is a multilayer. Thus, sublayers **172** and **174** are shown. Each of the sublayers **172** and **174** may be a barrier layer. In some embodiments, each of the sublayers **172** and **174** is a barrier to gold diffusion. In other embodiments, one sublayer **172** or **174** may be a barrier to gold diffusion while the other sublayer **174** or **172**, respectively, may have another purpose. This purpose may include functioning as a barrier to diffusion of another material and/or acting as a seed layer. Similarly, the diffusion barrier layer **180'** is a multilayer. The diffusion barrier layer **180'** includes sublayers **182** and **184**. In some embodiments, each of the sublayers **182** and **184** is a barrier to diffusion of pole material(s) such as Fe. In other embodiments, one sublayer **182** or **184** may be a barrier to pole material diffusion while the other sublayer **174** or **172**, respectively, may have another purpose. For example, the layer **182** may be a W layer and the layer **184** may be a Ru layer. In another embodiment, other configurations may be possible.

The HAMR transducer **120'** may share the benefits of the transducer **120**. For example, the presence of the diffusion barrier layer(s) **170'** and/or **180'** may prevent or reduce diffusion of constituents of the HAMR transducer **120'**. Thus, intermixing of the layers of the transducer **120'** may be reduced. Thus, performance and reliability of the HAMR transducer **120'** and the disk drive **100** may be enhanced. In addition, the layer **174** and/or **184** may be a corrosion barrier layer while the layer **172** and/or **182** may be a diffusion barrier layer. Thus, the diffusion barrier layer(s) **170'** and/or **180'** may function as both a diffusion barrier and a corrosion barrier.

FIGS. **4**A and **4**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120"** that may be part of the disk drive **100**. For clarity, FIGS. **4**A and **4**B are not to scale. For simplicity not all portions of the HAMR transducer **120"** are shown. In addition, although the HAMR transducer **120"** is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120"** is analogous to the HAMR transducer **120** and/or **120'**. Consequently, similar components have analogous labels. The HAMR transducer **120"** thus includes an NFT **130** including a disk **134** and a pin **130**, a waveguide **140** including cladding **144** and **146** and core **142**, heat sink **150**, heat spreader **152**, main pole **160** and diffusion barrier layer **170** that are analogous to the NFT **130** having the disk **134** and the pin **130**, the waveguide **140** including cladding **144** and **146** and core **142**, the heat sink **150**, the heat spreader **152**, the main pole **160** and the diffusion barrier layer **170**. The structure and function of the components in the transducer **120"** are thus analogous to those of the transducer **120** and/or **120'**. In addition, for clarity, some components of the transducer **120"** are not shown. For example, coils and the return pole depicted in FIG. **2**A are not shown in FIG. **4**A. However, such structures may be present.

In the embodiment shown in FIGS. **4**A and **4**B, the diffusion barrier layer **170** is present. Thus, the layer **170** is a barrier to gold diffusion. The diffusion barrier layer **170** is depicted as a single layer. In other embodiments, a multilayer may be used. However, the diffusion barrier layer **180/180'** has been omitted.

The HAMR transducer **120"** may share at least some of the benefits of the transducer(s) **120** and/or **120**. The presence of the diffusion barrier layer **170** may prevent or reduce diffusion of constituents of the HAMR transducer **120"**. For example, diffusion of constituents of the heat spreader **152**, heat sink **150**, and/or NFT **130** into the pole may be reduced or eliminated. Thus, intermixing of the layers of the transducer **120"** may be reduced. Thus, performance and reliability of the HAMR transducer **120"** and the disk drive **100** may be enhanced.

FIGS. **5**A and **5**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120'''** that may be part of the disk drive **100**. For clarity, FIGS. **5**A and **5**B are not to scale. For simplicity not all portions of the HAMR transducer **120'''** are shown. In addition, although the HAMR transducer **120**"; is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120'''** is analogous to the HAMR transducer **120**, **120'** and/or **120"**. Consequently, similar components have analogous labels. The HAMR transducer **120'''** thus includes an NFT **130** including a disk **134** and a pin **130**, a waveguide **140** including cladding **144** and **146** and core **142**, heat sink **150**, heat spreader **152**, main pole **160** and diffusion barrier layer **180** that are analogous to the NFT **130** having the disk **134** and the pin **130**, the waveguide **140** including cladding **144** and **146** and core **142**, the heat sink **150**, the heat spreader **152**, the main pole **160** and the diffusion barrier layer **180**. The structure and function of the components in the transducer **120'''** are thus analogous to those of the transducer **120**, **120'** and/or **120"**. In addition, for clarity, some components of the transducer **120''''** are not shown. For example, coils and the return pole depicted in FIG. **2**A are not shown in FIG. **5**A. However, such structures may be present.

In the embodiment shown in FIGS. **5**A and **5**B, the diffusion barrier layer **180** is present. However, the diffusion barrier layer **170**/**170'** has been omitted. Thus, the diffusion barrier layer **180** is a barrier to diffusion of one or more material(s) in the pole **160**. For example, in one embodiment, the diffusion barrier layer **180** is an Fe diffusion barrier. In some embodiments, the diffusion barrier layer **180** may also include a barrier to oxygen diffusion. Although depicted as a single layer, in some embodiments, the diffusion barrier layer **180** may be a multilayer.

The HAMR transducer **120'''** may share at least some of the benefits of the transducer(s) **120**, **120'** and/or **120"**. The presence of the diffusion barrier layer **180** may prevent or reduce diffusion of constituents of the HAMR transducer **120'''**. For example, diffusion of material(s) in the main pole **160** such as Fe, into the dielectric **146** may be reduced or eliminated. Thus, intermixing of the layers of the transducer **120'''** may be reduced. Thus, performance and reliability of the HAMR transducer **120'''** and the disk drive **100** may be enhanced.

FIGS. **6**A and **6**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120'''''** that may be part of the disk drive **100**. For clarity, FIGS. **6**A and **6**B are not to scale. For simplicity not all portions of the HAMR transducer **120''''** are shown. In addition, although the HAMR transducer **120''''** is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120''''** is analogous to the HAMR transducer **120**, **120'**, **120"** and/or **120'''**. Consequently, similar components have analogous labels. The HAMR transducer **120'''''** thus includes an NFT **130** including a disk **134** and a pin **130**, a waveguide **140** including cladding **144** and **146** and core **142**, heat sink **150**, main pole **160**, diffusion barrier layer **170** and diffusion barrier layer **180** that are analogous to the NFT **130** having the disk **134** and the pin **130**, the waveguide **140** including cladding **144** and **146** and core **142**, the heat sink **150**, the main pole **160**, the diffusion barrier layer **170**/**170'** and the diffusion barrier layer **180**/**180'**, respectively. The structure and function of the components in the transducer **120''''** are thus analogous to that in the transducer **120**/**120'**/**120"**/**120'''**. In addition, for clarity, some components of the transducer **120''''** are not shown. For example, coils and the return pole depicted in FIG. **2**A are not shown. However, such structures may be present.

In the embodiment shown in FIGS. **6**A and **6**B, the heat spreader has been omitted. The diffusion barrier layer **170** is depicted as a single layer. In other embodiments, a multilayer may be used. The diffusion barrier layer **170** is a barrier to gold diffusion. However, a portion of the diffusion barrier layer **170** is between the main pole **160** and the cladding **146**. Thus, the diffusion barrier layer **170** may also be desired to function as a diffusion barrier for material(s) in the main pole **160**. For example, the diffusion barrier layer **170** may be desired to be a barrier to diffusion of Fe. Thus, the materials described above that are suitable for use in both the structures **170** and **180** may be used in the diffusion barrier layer **170**. For example, the diffusion barrier layer **170** may be a W layer. Similarly, the diffusion barrier layer **180** is also a single layer. In other embodiments, the diffusion barrier layer **180** may be a multilayer. In another embodiment, other configurations may be possible.

The HAMR transducer **120''''** may share the benefits of the transducers **120**, **120'**, **120"** and/or **120'''**. For example, the presence of the diffusion barrier layer(s) **170** and/or **180** may prevent or reduce diffusion of constituents of the HAMR transducer **120''''**. Thus, intermixing of the layers of the transducer **120''''** may be reduced. Thus, performance and reliability of the HAMR transducer **120''''** and the disk drive **100** may be enhanced.

FIGS. **7**A and **7**B depict side and ABS views of an exemplary embodiment of a portion of the HAMR transducer **120'''''** that may be part of the disk drive **100**. For clarity, FIGS. **7**A and **7**B are not to scale. For simplicity not all portions of the HAMR transducer **120'''''** are shown. In addition, although the HAMR transducer **120'''''** is depicted in the context of particular components other and/or different components may be used. Further, the arrangement of components may vary in different embodiments. The HAMR transducer **120'''''** is analogous to the HAMR transducer **120**, **120'**, **120"**, **120'''** and/or **120''''**. Consequently, similar components have analogous labels. The HAMR transducer **120''''** thus includes an NFT **130** including a disk **134** and a pin **130**, a waveguide **140** including cladding **144** and **146** and core **142**, main pole **160**, diffusion barrier layer **170** and diffusion barrier layer **180** that are analogous to the NFT **130** having the disk **134** and the pin **130**, the waveguide **140** including cladding **144** and **146** and core **142**, the main pole **160**, the diffusion barrier layer **170**/**170'** and the diffusion barrier layer **180**/**180'**, respectively. The structure and function of the components in the transducer **120''''** are thus analogous to that in the transducer **120**/**120'**/**120"**/**120''''120''''**. In addition, for clarity, some components of the transducer **120''''** are not shown. For example, coils and the return pole depicted in FIG. **2**A are not shown. However, such structures may be present.

In the embodiment shown in FIGS. **7**A and **7**B, the heat spreader and the heat sink have been omitted. The diffusion barrier layer **170** may thus be in physical contact with the NFT **130** and the main pole **160**. The diffusion barrier layer **170** is depicted as a single layer. In other embodiments, a multilayer may be used. The diffusion barrier layer **170** is a barrier to diffusion of material(s) in the NFT **130** such as gold. However, a portion of the diffusion barrier layer **170** is between the main pole **160** and the cladding **146**. Thus, the diffusion barrier layer **170** may also be desired to function as a diffusion barrier for material(s) in the main pole **160**. For example, the diffusion barrier layer **170** may also be desired to be a barrier to diffusion of Fe, Ni and Co. Thus, the materials described above that are suitable for use in both the structures **170** and **180** may be used in the diffusion barrier layer **170**. For example, the diffusion barrier layer **170** may be a W layer. Similarly, the diffusion barrier layer **180** is also a single layer. In other embodiments, the diffusion barrier layer **180** may be a multilayer. In another embodiment, other configurations may be possible.

The HAMR transducer **120'''''** may share the benefits of the transducers **120**, **120'**, **120''**, **120'''** and/or **120''''**. For example, the presence of the diffusion barrier layer(s) **170** and/or **180** may prevent or reduce diffusion of constituents of the HAMR transducer **120'''''**. Thus, intermixing of the layers of the transducer **120'''''** may be reduced. Thus, performance and reliability of the HAMR transducer **120'''''** and the disk drive **100** may be enhanced. Various configurations of the HAMR transducer, including diffusion barrier layers have been described herein. In other embodiments, one or more features of the transducers **120**, **120'**, **120''**, **120'''**, **120''''** and/or **120'''''** may be combined.

FIG. **8** is a flow chart depicting an exemplary embodiment of a method **200** for fabricating a HAMR write transducer. The method **200** may be used in fabricating transducers such as the transducers **120**, **120'**, **120''**, **120'''**, **120''''** and/or **120'''''**, though other transducers might be so fabricated. For clarity, the method **200** is described in the context of the transducer **120** depicted in FIGS. **1**, **2**A and **2**B. For simplicity, some steps may be omitted, performed in another order, interleaved and/or combined. The magnetic recording transducer being fabricated may be part of a merged head that also includes a read head (not shown) and resides on a slider (not shown) in a disk drive. The method **200** is also described in the context of providing a single magnetic recording transducer. However, the method **200** may be used to fabricate multiple transducers at substantially the same time. The method **200** and system are also described in the context of particular layers. However, in some embodiments, such layers may include multiple sub-layers. The method **200** also may commence after formation of other portions of the transducer.

The return pole **162** is optionally provided, via step **202**. In some embodiments, step **202** includes forming the pedestal at the ABS for the return pole **162**. An insulator may also be provided on the first pole. The waveguide **140** may be provided, via step **204**. Step **204** generally includes forming cladding layers surrounding a core layer. The NFT **130** may be provided, via step **206**. The NFT **130** is typically a metal disk **134** as well as a pin **132**. Step **206** may thus include multiple substeps. For example, the material(s) for the disk **134** and/or pin **132** may be deposited, a mask covering the portions of the material(s) corresponding to the NFT **130** provided and the exposed portions of the material(s) may be lifted off. In other embodiments, a lift-of process may be used for forming the disk **134** and/or the pin **132**.

The heat sink **150** and/or heat spreader **152** are optionally provided, via step **208**. Step **208** may include depositing and patterning high thermal conductivity material(s), such as Au. The main pole **160** is provided, via step **210**. Step **210** typically includes multiple deposition, masking and removal steps. Formation of the leading surface, leading and/or trailing bevels, an NFT-facing surface parallel to the top of the NFT, the ABS-facing surface and/or other features of the main pole **160** may also be completed as part of step **210**.

One or both of the diffusion barrier layers **170/170'** and/or **180/180'** are formed, via step **212**. Formation of the diffusion barrier layer **170/170'** in step **212** may occur before formation of the main pole **160** in step **210**. Thus, at least part of step **212** may be interleaved with or occur before at least part of step **212**. The diffusion barrier **180/180'** may be formed before or after formation of the main pole **160**. For example, the diffusion barrier **180/180'** may be deposited in a trench and the main pole provided in the trench. Alternatively, at least part of the main pole **160** may be formed first and the diffusion barrier layer **180/180'** provided on the main pole **160**.

The coil(s) **145** may be provided, via step **214**. Step **214** may include multiple depositing and patterning steps such that the turns on both sides of the main pole **160** are fabricated. The shield **192** may also be fabricated, via step **216**. Step **216** may include manufacturing the pedestal **193**. Fabrication of the transducer may then be completed, via step **218**.

Using the method **200**, the HAMR transducer **120**, **120'**, **120''**, **120'''**, **120''''** and/or **120'''''** may be fabricated. The benefit(s) of one or more of the HAMR transducer(s) **120**, **120'**, **120''**, **120'''**, **120''''** and/or **120'''''** may thus be achieved.

FIG. **9** is a flow chart depicting an exemplary embodiment of a method **220** for fabricating a main pole and diffusion barrier layer of a HAMR write transducer FIGS. **10-18** are diagrams depicting side views of another exemplary embodiment of a HAMR transducer **300** during fabrication using the method **220**. For clarity, FIGS. **10-18** are not to scale. Further, although FIGS. **10-18** depict the ABS location (location at which the ABS is to be formed) and the ABS at a particular point in the pole, other embodiments may have other locations for the ABS. Further, the transducer **300** extends beyond the ABS location in FIGS. **10-18** because the device has not yet been lapped to the ABS. Referring to FIGS. **8-18**, the method **220** is described in the context of the HAMR transducer **300**. However, the method **220** may be used to form another device (not shown). The HAMR transducer **300** being fabricated may be part of a merged head that also includes a read head (not shown in FIGS. **9-18**), a laser (not shown in FIGS. **9-18**) and resides on a slider (not shown) in a disk drive. In addition, other portions of the HAMR transducer **300**, such as the return pole, shield(s) and coil(s) are not shown for clarity. The method **220** also may commence after formation of other portions of the HAMR transducer **300**. For example, a tantalum oxide core for the waveguide may have been formed. The method **220** is also described in the context of providing a single HAMR transducer **300** and a single composite NFT in the HAMR transducer **300**. However, the method **220** may be used to fabricate multiple transducers and/or multiple heat sinks per transducer at substantially the same time. The method **220** and device **300** are also described in the context of particular layers. However, in some embodiments, such layers may include multiple sublayers.

The layer(s) for the first barrier layer are deposited, via step **222**. Step **222** is optional and performed only if a bottom barrier layer, such as the barrier layer **170/170'** depicted in FIGS. **1-3**B, is to be provided. Referring back to FIGS. **9-18**, the barrier layer deposited in step **222** may be a barrier to gold and/or other material(s) that may diffuse from the NFT, heat sink and/or heat spreader. Step **222** may include depositing a desired thickness of one or more of W, Ru, Ta, TaN, indium oxide, tungsten nitride, titanium nitride, titanium tungsten, tungsten carbonitride, tungsten disilicide, titanium tungsten silicide and Ni. For example, in one embodiment, four nanometers of W may be deposited in step **222**.

FIG. **10** depicts the transducer **300** after step **222** is performed. The transducer **300** includes a waveguide **310**, NFT **320**, heat sink **330** and head spreader **332** that have already been at least partially fabricated. The waveguide **310** includes cladding layers **314** and **316** and core **312**. The NFT **320** includes a disk **324** and a pin **322**. In some embodiments, the disk **324** and pin **322** are both metallic. For example gold or a gold alloy may be used for the disk **324** and pin **322**. However, in other embodiments, the disk **324** and pin **322** may be made of different materials. The heat sink **330** may include an AuCuAg alloy. Although not shown, the heat sink **330** may also include a Cr layer below the AuCuAg alloy and a Cr capping layer on the AuCuAg alloy. In some embodiments, the heat sink **330** includes nominally four nanometers of Cr below and above approximately seven hundred nanometers of an alloy. The heat spreader **332** may be an Au structure. Although not shown, the heat sink **330** may also include a Cr layer below the Au layer and a Cr capping layer on the Au layer. In some embodiments, the heat spreader **332** includes nominally four nanometers of Cr below and above the Au layer. In some such embodiments, the Cr capping layer for the heat sink **330** is also the Cr bottom layer for the heat spreader **332**. A layer barrier **340** provided in step **222** is also shown. The barrier layer **340** may prevent material(s) from the structures **330**, **332** and/or **320** from diffusing through the barrier layer **340**. In some embodiments, the barrier layer **340** may also be a barrier to diffusion of material(s) from the main pole (described below). Although depicted as a single layer, the barrier layer **340** may be a multilayer.

A seed layer for the main pole is provide, via step **224**. In some embodiments, step **224** includes providing a magnetic seed layer. In some embodiments, a multilayer seed may be provided in step **224**. For example, a bilayer of NiCr and CoFe may be deposited. The material(s) for the main pole are provided, via step **226**. In some embodiments, step **226** includes providing a photoresist mask that has an aperture corresponding to the main pole. At least part of the aperture has the shape and location desired for the main pole. The magnetic materials for the main pole are also provided. For example, the main pole materials may be plated in step **224**. FIG. **11** depicts the transducer **300** after step **226** is performed. Thus, a seed layer **342** provided in step **224** is shown. Also shown are mask **344** and main pole materials **350** provided in step **226**. The main pole material(s) **350** are magnetic and thus may include Fe, Co and/or Ni. The saturation magnetization of the main pole material(s) **350** are desired to be high. In some embodiments, the saturation magnetization is greater than 2.3 T. In some such embodiments, the main pole saturation magnetization is 2.4 T.

The mask **344** is removed, via step **228**. Step **228** may include performing a photoresist strip. Also in step **228**, portions of the seed layer **342** exposed after the removal of the mask **344** are removed. For example, an ion beam etch may be performed after the photoresist mask **344** is removed. FIG. **12** depicts the transducer **300** after step **228** is performed. Thus, the mask **344** has been removed. In addition, the seed layer **342** for the main pole material(s) **350** remains only under the main pole material(s).

The layer(s) for the second barrier layer are deposited, via step **230**. Step **230** is optional and performed only if another barrier layer, such as the barrier layer **180**/**180'** depicted in FIGS. **1-3**B, is to be provided. Referring back to FIGS. **9-18**, the barrier layer deposited in step **230** may be a barrier to Fe and/or other material(s) that may diffuse from the man pole material(s) **250**. Step **230** may include depositing a desired thickness of one or more of W, Ru and other material(s) that are Fe diffusion barrier. For example, in one embodiment, four nanometers of W may be deposited in step **230**. In some embodiments, an oxygen diffusion barrier may also be provided in step **230**. FIG. **13** depicts the transducer **350** after step **230** is performed. Thus, barrier layers **362** and **364** are shown. In this embodiment, two barrier layers **362** and **364** are shown. The barrier layer **362** may be a W layer that is a gold and Fe barrier layer, while the layer **364** may be a Ru oxygen barrier layer. In other embodiments, barrier layer **364** may be a gold and Fe barrier layer, while the layer **362** may be a Ru oxygen barrier layer. In another embodiments, another number of layers (fewer or more) may be deposited in step **230**. In the embodiment shown, the barrier layers **362** and **364** may be full film deposited and thus cover the device area.

The portion of the barrier layers **362** and **364** that are on the top of the main pole material(s) **350** are removed, via step **232**. In some embodiments, step **232** is an anisotropic removal step. Thus, the part of the barrier layers **362** and **364** on vertical or near vertical surfaces remain, while the part of the barrier layers **362** and **364** on horizontal or substantially horizontal surfaces is removed. In this case, a horizontal surface is substantially perpendicular to the ABS. For example step **232** may include performing an ion beam etch at an angle near perpendicular to the horizontal surface. In some embodiments, the ion beam may be at an angle of not more than ten degrees from normal to the horizontal surfaces. FIG. **14** depicts the transducer **250** during step **232**. The ion beam is shown by arrows at an angle, θ, from normal to the horizontal surfaces. As discussed above, θ may not exceed ten degrees. The portion of the layers **362** and **364** has also been removed from the top of the main pole material(s) **350** and adjacent regions on top of the dielectric **316**.

A dielectric spacer layer is deposited, via step **234**. Step **234** may include depositing a layer of silicon dioxide. For example, at least twenty nanometers and not more than eighty nanometers may be deposited. In some embodiments, nominally sixty nanometers are deposited. FIG. **15** depicts the transducer **300** after step **234** is performed. Thus, the dielectric layer **370** is shown.

The region around the main pole material(s) **350** may be covered by a mask and a field etch may be carried out, via step **236**. For example, a reactive ion etch may be performed in step **236**. Thus, unwanted portions of the additional dielectric **370** and barrier layer(s) **340**, **362** and/or **364** may be removed from the field. FIG. **16** depicts the transducer **300** after this step. Thus, the mask **372** is shown. Also in step **236**, a wet etch may be performed to remove magnetic materials in the field region and fencing removed from the edges of the barrier layers **362** and **364**.

A dielectric refill step is performed, via step **238**. The mask **372** may thus be removed and a dielectric deposited. In some embodiments, silicon dioxide is deposited. For example, physical vapor deposition may be used. FIG. **17** depicts the transducer **300** after step **238** is performed. Thus, the dielectric **374** has been provided.

A planarization is performed, via step **240**. In some embodiments, a chemical mechanical planarization (CMP) is carried out in step **240**. Thus, the topography of the transducer **300** may be planarized. In addition, a portion of the main pole material(s) **350** may be removed to provide a pole of the desired height. FIG. **18** depicts the transducer **300** after step **240** is performed. Thus, the main pole **350** has been substantially formed. Fabrication of the transducer **300** may then be completed.

Using the method **220**, the HAMR transducer **300** may be fabricated. Thus, the barrier layer **340** and/or the barrier layers **362** and **364** may be provided. The barrier layers **340**, **362**, and/or **364** may prevent or reduce interdiffusion of materials in the transducer **300** during operation. Performance and/or reliability of the transducer **300** may thus be improved.

We claim:

1. A heat assisted magnetic recording (HAMR) write apparatus coupled with a laser for providing energy and having an air-bearing surface (ABS) configured to reside in proximity to a media during use, the HAMR write apparatus comprising:

a waveguide optically coupled with the laser and for directing the energy from the laser toward the ABS;

a near field transducer (NFT) proximate to the ABS, the NFT being optically coupled with the waveguide, for focusing the energy onto a region of the media and including a metal portion having a metal surface;

a main pole configured to write to the region of the media, the main pole having atop, a bottom, and a plurality of sides;

at least one of a first diffusion barrier layer and a second diffusion barrier layer, the first diffusion barrier layer being between at least the NFT and the bottom of the pole, the first diffusion barrier sharing having a first surface and a second surface opposite to the first surface, the first surface adjoining at least one of the metal surface of the metal portion of the NFT and an additional metal surface, the second surface adjoining the bottom of the pole, the second diffusion barrier layer being adjacent to the plurality of sides of the main pole, the first diffusion barrier layer including a barrier to diffusion of a gold-containing material, the second diffusion barrier layer including a barrier to diffusion of at least one constituent of the main pole, the first diffusion barrier layer including at least one of a W layer, a Ta layer, an indium oxide layer, a tungsten nitride layer, a titanium tungsten layer, a tungsten carbonitride layer, a tungsten disilicide layer, a titanium tungsten silicide layer and a Ni layer, the write apparatus including the first diffusion barrier; and

at least one coil for energizing the main pole.

2. The HAMR write apparatus of claim **1** further comprising:

a heat sink thermally coupled with the NFT and between the NFT and the main pole, the first diffusion barrier layer being between the heat sink and the main pole and being a barrier to diffusion of the heat sink to the main pole, the heat sink including the additional metal surface.

3. The HAMR write apparatus of claim **1** further comprising:

a heat sink thermally coupled with the NFT and between the NFT and the main pole, the first diffusion barrier layer being between the heat sink and the main pole; and

a heat spreader thermally coupled with the heat sink, at least a portion of the heat spreader adjacent to the bottom of the pole, the first diffusion barrier layer being between the heat spreader and the bottom of the main pole and being a barrier to diffusion of the heat spreader to the main pole, the heat spreader including the additional metal surface.

4. The HAMR write apparatus of claim **1** wherein the first diffusion barrier layer includes at least two sublayers.

5. The HAMR write apparatus of claim **1** further comprising:

at least one dielectric adjacent to the plurality of sides of the main pole, the second diffusion barrier layer being between the plurality of sides of the main pole and the at least one dielectric.

6. The HAMR write apparatus of claim **5** wherein the second diffusion barrier layer includes at least two sublayers.

7. The HAMR write apparatus of claim **6** wherein the second diffusion barrier layer includes a W sublayer and a Ru sublayer on the W sublayer.

8. The HAMR write apparatus of claim **6** wherein the at least one constituent includes Fe.

9. A heat assisted magnetic recording (HAMR) disk drive comprising:

a media;

a slider;

a laser for providing energy; and

a HAMR write transducer coupled with the slider, the HAMR write transducer having air-bearing surface (ABS), a main pole, a waveguide, least one coil, a near-field transducer (NFT) and at least one of a first diffusion barrier layer and a second diffusion barrier layer, the waveguide being optically coupled with the laser and directing a portion of the energy toward the ABS, the NFT being proximate to the ABS, the NFT being optically coupled with the waveguide and for focusing the energy onto a region of the media, the NFT including a metal portion having a metal surface, a main pole configured to write to the region of the media, the main pole having a top, a bottom, and a plurality of sides, the first diffusion barrier layer being between at least the NFT and the bottom of the pole, the first diffusion barrier layer including a barrier to diffusion of a gold-containing material, the first diffusion barrier sharing having a first surface and a second surface opposite to the first surface, the first surface adjoining at least one of the metal surface of the metal portion of the NFT and an additional metal surface, the second surface adjoining the bottom of the pole, the second diffusion barrier layer being adjacent to the plurality of sides of the main pole, the second diffusion barrier layer including a barrier to diffusion of at least one constituent of the main pole, the first diffusion barrier layer includes at least one of a W layer, a Ta layer, an indium oxide layer, a tungsten nitride layer, a titanium tungsten layer, a tungsten carbonitride layer, a tungsten disilicide layer, a titanium tungsten silicide layer and a Ni layer, the HAMR write transducer including the first diffusion barrier, the at least one coil for energizing the main pole.

10. A method for fabricating a heat assisted magnetic recording (HAMR) write apparatus coupled with a laser for providing energy and having an air-bearing surface (ABS) configured to reside in proximity to a media during use, the method comprising:

providing a waveguide optically coupled with the laser and directing a portion of the energy from the laser toward the ABS;

providing a near field transducer (NFT) proximate to the ABS, the NFT being optically coupled with the waveguide, for focusing the energy onto a region of the media and including a metal portion having a metal surface;

providing a main pole configured to write to the region of the media, the main pole having a top, a bottom, and a plurality of sides;

providing at least one of a first diffusion barrier layer and a second diffusion barrier layer, the first diffusion barrier layer being between at least the NFT and the bottom of the pole, the first diffusion barrier layer including a barrier to diffusion of a gold-containing material, the first diffusion barrier sharing having a first surface and a second surface opposite to the first surface, the first surface adjoining at least one of the metal surface of the metal portion of the NFT and an additional metal surface, the second surface adjoining the bottom of the pole, the second diffusion barrier layer being adjacent to the plurality of sides of the main pole, the second diffusion barrier layer including a barrier to diffusion of at least one constituent of the main pole, the first diffusion barrier layer includes at least one of a W layer, a Ta layer, an indium oxide layer, a tungsten nitride layer, a titanium tungsten layer, a tungsten carbonitride layer, a tungsten disilicide layer, a titanium tungsten silicide layer and a Ni layer, the step of providing at least one of the first diffusion barrier and the second diffusion barrier further includes providing the first diffusion barrier; and

providing at least one coil for energizing the main pole.

11. The method of claim **10** further comprising:

providing a heat sink thermally coupled with the NFT and between the NFT and the main pole, the first diffusion barrier layer being between the heat sink and the main pole and being a barrier to diffusion of the heat sink to the main pole, the heat sink including the additional metal surface.

12. The method of claim **10** further comprising:

providing a heat sink thermally coupled with the NFT and between the NFT and the main pole, the first diffusion barrier layer being between the heat sink and the main pole; and

providing a heat spreader thermally coupled with the heat sink, at least a portion of the heat spreader adjacent to the bottom of the pole, the first diffusion barrier layer being between the heat spreader and the bottom of the main pole and being a barrier to diffusion of the heat spreader to the main pole, the heat spreader including the additional metal surface.

13. The method of claim **10** wherein the first diffusion barrier layer includes at least two sublayers.

14. The method of claim **10** further comprising:

providing at least one dielectric adjacent to the plurality of sides of the main pole, the second diffusion barrier layer being between the plurality of sides of the main pole and the at least one dielectric, the second diffusion barrier layer including a barrier to diffusion of at least one constituent of the main pole to the at least one dielectric.

15. The method of claim **14** wherein the step of providing the at least one of the first diffusion barrier layer and the second diffusion barrier layer includes providing the second diffusion barrier layer, the step of providing the second diffusion barrier layer further includes:

depositing a layer including the barrier to diffusion on the top and the plurality of sides of the main pole;

ion milling at least the barrier on the top of the main pole at a milling angle, the milling angle being at least zero and not more than ten degrees from normal to a substrate surface, a portion of the barrier on top of the main pole being removed; and

depositing a dielectric covering the main pole and the second diffusion barrier layer.

16. The method of claim **15** wherein the step of providing the second diffusion barrier layer further includes:

depositing an oxygen barrier layer on the layer.

17. The method of claim **16** wherein the barrier includes a W sublayer and the oxygen barrier layer includes a Ru sublayer.

18. The HAMR write apparatus of claim **1** wherein the apparatus includes the first diffusion barrier layer and the second diffusion barrier layer, the second diffusion barrier layer includes a barrier to diffusion of at least one constituent of the main pole, the first barrier layer extending along the bottom of the main pole from the ABS to the back of the main pole, a portion of the second diffusion barrier layer being adjacent to the back of the main pole.

19. The HAMR disk drive of claim **9** wherein the HAMR transducer includes the first diffusion barrier layer and the second diffusion barrier layer, the second diffusion barrier layer includes a barrier to diffusion of at least one constituent of the main pole, the first diffusion barrier layer extending along the bottom of the main pole from the ABS to the back of the main pole, a portion of the second diffusion barrier layer being adjacent to the back of the main pole.

20. The method of claim **10** wherein the HAMR transducer includes the first diffusion barrier layer and the second diffusion barrier layer, the second diffusion barrier layer includes a barrier to diffusion of at least one constituent of the main pole, the first diffusion barrier layer extending along the bottom of the main pole from the ABS to the back of the main pole, a portion of the second diffusion barrier layer being adjacent to the back of the main pole.

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